THE ILLUMINATING ENGINEER

LIGHT
LAMPS
FITTINGS
AND
ILLUMINATION

THE JOURNAL OF
GOOD LIGHTING

Official Organ of the Illuminating Engineering Society

FOUNDED IN LONDON 1908

Edited by
LEON GASTER

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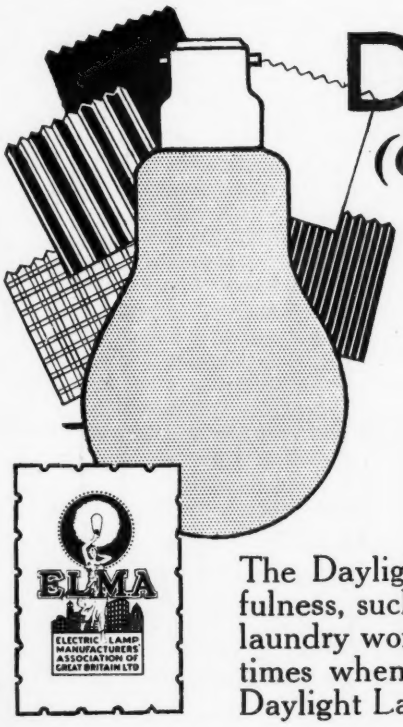
Special Features:

Artificial Light as an Aid to Aerial Navigation (*continued*)—The B.E.S.A. Draft Standard Specification for Street Lighting — The Economics of Light Production — The Development of Gas Supply in Liverpool — Correspondence — Reviews of Books — News from Abroad, etc.

Electric Lamps and their Uses. No 3



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Problems in Illuminating Engineering and Their Solution

THE meeting of the Illuminating Engineering Society held at the E.L.M.A. Lighting Service Bureau on March 22nd represented a new and, we believe, successful departure. We are giving in this issue (p. 140) a brief summary of the proceedings, which will be dealt with more fully in our next number. Briefly the plan adopted was to devote the evening to a series of short communications by different authors, each raising some special problem in illuminating engineering and suggesting possible solutions. In this way quite a variety of topics were discussed and much interesting information presented.

The first item on the programme was a description by Mr. L. M. Tye of a novel problem in decorative lighting, namely, the lighting of the Greyhound Theatre and Dance Hall at Croydon. This large hall is put to varied uses. It may be thrown in to adjoin the restaurant so that diners can witness the entertainment, or it may be screened off and used for special events, such as dramatic performances, kinema displays or dances. The lighting has to be varied according to the use to which the hall was put, and the method of combining general indirect lighting from a large central chandelier with special colour lighting was novel and interesting.

Other subsequent items were the description by Mr. W. Millner of the unusual cornice lighting installation round the dome of the Cathedral of St. Sophia (St. Petersburg Square) and the contribution by Mr. H. H. Long explaining how the artificial lighting of a greyhound racing track was designed. In view of the growing interest being taken in this novel form of sport (in which the greyhounds chase an "electric" hare) and the probable erection of other similar racecourses in the near future, this problem deserves study. The primary question—the reconciliation of adequate illumination of the track with absence of glare in the eyes of spectators is one that must often occur in lighting large arenas where spectacles are staged, and the discussion was therefore particularly instructive.

Mr. L. E. Buckell dealt with two special problems in shop-window lighting, involving the skilful design of a harmonious colour scheme, and an allied and somewhat difficult question —the lighting of windows occupying "island sites"—was later discussed by Mr. G. Herbert. Mr. J. S. Dow gave a brief summary of recent methods of improving the efficiency of kinema and lantern projectors, the luminous efficiency of which is notoriously low at present, and also presented a problem dealt with by Mr. A. Cunnington—the design of platform lighting on a suburban railway station so as to prevent the eyes of drivers being dazzled by glare. The experience in this case, that exposed platform lights of quite moderate brilliancy interfered with the view of distant signals by drivers, has an obvious bearing on street lighting, where drivers of motor cars may be troubled by the sight of light sources which might possibly give little concern to the pedestrian. Other matters dealt with in the discussion included the lighting of the gardens at the Ideal Home Exhibition (Mr. Herbert), the lighting of offices and the lighting of escalators and railway coaches during repair (Mr. S. G. Elliott).

It was generally agreed that the evening was a most successful one. There is much to be said for such informal discussions in which all present can join, and in which much may be learned. No doubt this procedure will be followed at other meetings of the Society in the future. We are now approaching the close of the present session, and we think it will be generally conceded that the meetings have been exceptionally interesting and instructive. The preparation of the programme for the next session should be begun very soon, and we hope that members will help the Hon. Secretary by sending in suggestions for future discussions or by offering to read papers on subjects of which they have special knowledge. The Society covers a very wide ground, and there is room for many forms of meetings—purely technical and scientific discussions, meetings devoted to topics of public interest, in which representatives of kindred societies can join, and informal discussions and visits to lighting installations of interest, etc. In order to deal with these varied subjects it may be desirable to extend the list of meetings, but how far it is possible to do so depends on two essential factors, increased financial support and active co-operation by members of the Society in helping the Council to arrange an attractive programme.

The visit to the National Physical Laboratory on April 26th, which occurred just before this issue went to press, was also well attended and most successful. An account of the visit, together with Mr. Buckley's paper reviewing the work of the Photometric Section of the National Physical Laboratory, will appear in our next issue. The paper and discussion showed very clearly how the practical applications of photometry have extended since 1908, when a paper dealing with the Photometric Laboratory at the N.P.L. was contributed by Mr. C. C. Paterson and Dr. E. H. Rayner to the very first issue of *The Illuminating Engineer*.

Street Lighting and Public Safety

IN this issue (pp.141-146) we are presenting the complete discussion on the Standard Specification for Street Lighting drafted by the B.E.S.A. sub-committee. It was generally agreed that this was a most informative discussion. In our last issue we commented on this discussion in some detail, and it seems unnecessary to say more at the moment. We should, however, welcome suggestions from readers or members of the Illuminating Engineering Society who were unable to be present at the discussion, but who may have points that they desire to raise.

On one point everyone will be agreed—the need for a standard specification for public lighting, such as will afford a uniform basis for tendering and will help to bring about certain generally accepted principles in street lighting. Its general adoption would at least have the effect of drawing attention to the importance of the subject.

That the vital importance of adequate street lighting in relation to traffic is not even now properly appreciated is, we think, illustrated by the discussion in the House of Commons on the Road Transport Lighting Bill which passed its second reading on April 1st. This Bill has to do exclusively with lights on vehicles, and it may be thought that public lighting did not come within the scope of the discussion. Yet, in fact, the discussion did cover a very wide field, some speakers viewing with alarm the prospect that ultimately everything except fast-moving motor traffic would be driven off the roads altogether. It does not seem to be sufficiently realized that the safety, both of pedestrians and vehicles, is not merely a matter of attaching lights to them, but that the provision of adequate public lighting is their greatest safeguard, besides rendering unnecessary the very powerful motor headlights which are at present regarded as a danger owing to excessive glare.

The figures quoted by Sir Park Goff in regard to accidents occurring by day and by night were particularly instructive. In the accompanying table we reproduce these figures, together with some derived ratios showing the proportion of accidents occurring by day and by night, in the last column: —

Year	Number of Accidents during year		Percentage Ratio
	By day	By night	Accidents by night / Accidents by day
Fatal: —			
1920	495	143	29%
1926	687	316	46%
Non-fatal: —			
1920	16,225	3,338	21%
1926	35,130	10,906	31%

When one considers the very much smaller volume of traffic by night and the fact that during a great proportion of the hours of darkness roads are practically not being used at all either by vehicles or pedestrians, the proportion of accidents occurring at night is obviously high. Even more significant, however, is the great increase in the ratio during the period 1920 to 1926. In the latter year the number of fatal road accidents occurring at night was nearly half the number occurring by day.

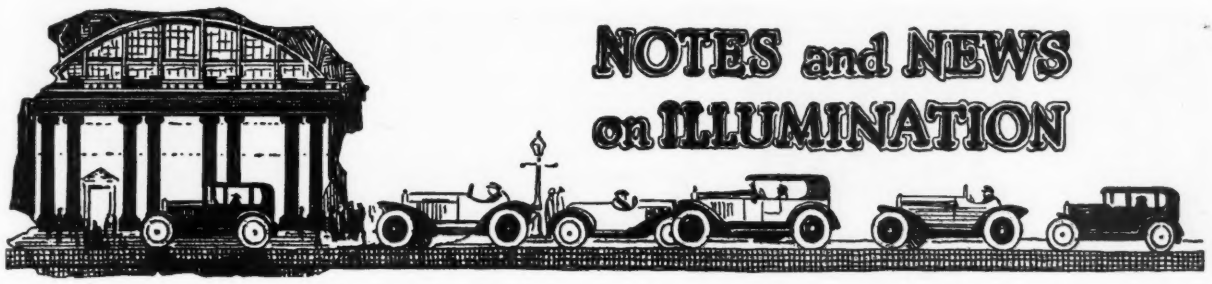
This surely shows clearly enough how, as traffic becomes faster and the roads become more crowded, the importance of adequate illumination becomes continually greater. In the case of arterial roads between cities, specially constructed at considerable cost to cope with the flow of traffic, much of the advantage to be derived from them will be lost if they cannot be rendered safe for night traffic by appropriate illumination.

Street Lighting and the Central Station

WE have received from Mr. L. A. S. Wood, who is manager of the Street-Lighting Section of the Westinghouse Electric and Manufacturing Co. (U.S.A.), a copy of a booklet recently issued by this company under the above title. Whilst naturally drafted to apply to American conditions, most of the arguments in favour of better street lighting would apply equally well to this country. It is pointed out that the average citizen is prone to think of street lights as something extremely remote from his ken. Yet the lights belong to *him*, and not to the electric service company. As a taxpayer and part owner of the street-lighting system he is helping to promote safety and comfort on the streets, to advertise the prosperity and civic alertness of his community, to assist in policing the city and facilitating the control of traffic. The problem is how to bring this aspect home to the general public, and the booklet illustrates an attractive poster designed for this purpose. The writer, in the course of the recent discussion on " Illuminating Engineering " before the Institution of Electrical Engineers, pointed out that in these and other cases it is no use preaching to the converted. Those participating in the illuminating engineering movement are well aware of the importance of good public lighting. The great need in this country, as in others, is to bring home the importance of the matter to the general public, on whose opinion as ratepayers the prospects of improvements in street lighting mainly depend.

But it is equally important that electric supply undertakings should recognize the value of the street-lighting business to them. Street lighting, on a 4,000-hour schedule, has a load factor of 46 per cent., whereas the average residence load is only 15 per cent. It is largely an " off-peak " load, and it has also the important function of leading to developments in other fields of lighting. For example, inadequately lighted shops appear dim and dingy in well-illuminated streets, so that an improvement in public lighting brings in its train better shop lighting.

Reviewing future progress, the booklet draws attention to the important field of highway lighting, i.e., the illumination of the chief interurban thoroughfares. The continually increasing flow of motor traffic makes adequate lighting a necessity for these highways, and the cost of installation is less than is generally supposed. It is estimated that where an existing power line is reasonably accessible the cost of installing a highway-lighting system will not exceed 5 per cent. of the expense of laying down a " Class C " highway (i.e., a surface of bituminous concrete, portland cement, concrete or brick, costing about 36,100 dollars a mile). The chief difficulty in the United States, as in this country, is the decision as to what body is to undertake the expense of such lighting. Nevertheless, in several States, Michigan, New York, Massachusetts and California, fairly continuous systems of highway lighting are developing. It is estimated that rather more than 3,000,000 miles of highways exist in the United States, of which roughly 500,000 miles are surfaced. If this length of highway was adequately lighted a potential load of 5,530,000,000 kw.-hours would result—surely an inducement to electric supply undertakings to take an interest in this field! It cannot be doubted that great opportunities likewise exist in this country, where much money has recently been expended on the development of arterial roads.



Institution of Public Lighting Engineers

FORTHCOMING ANNUAL CONFERENCE.

Readers will recall that the Annual Conference of the Institution of Public Lighting Engineers is to be held in Brighton this year, during September 12th to 15th. An address will be delivered by the incoming President, Mr. Alex. W. Cramb, and various papers of interest have been arranged. The public lighting of Brighton will be described by Mr. John Christie (Electrical Engineer and Manager, County Borough of Brighton), and a paper entitled "Road Traffic and Public Lighting, as seen by a Chief Constable," will be read by Mr. R. L. Matthews (Chief Constable of the City of Leeds). The B.E.S.A. Standard Specification on Street Lighting will be dealt with by Capt. L. B. W. Jolley and Mr. R. Watson. An exhibition of modern street-lighting appliances is also being arranged. Further particulars may be obtained from the Hon. Secretary, Capt. W. J. Liberty, General Buildings, Aldwych, London, W.C.2.

Industrial Lighting

On March 16th a lecture on the above subject, forming one of the "Works Organization and Management" series, was delivered at the Polytechnic (Regent Street, London) by Mr. L. Gaster. The audience was augmented by the addition of the class on illuminating engineering conducted by Mr. Short, who said a few words of introduction. The earlier part of the lecture was devoted to an account of the industrial benefits of good lighting, in preventing accidents, and in removing handicaps to the worker which are responsible for industrial fatigue and impede production. Reference was made to the work of the Illumination Research Committee, especially in showing the effect of illumination on the accuracy and output of compositors, and to the conclusions of the Home Committee on Lighting in Factories and Workshops. The lecture was illustrated by lantern slides showing good and bad methods of lighting, and the account of the part played by colour in certain industries (colour-printing, dyeing and textile trades, etc.) was effectively illustrated by means of the handy demonstration box loaned for the occasion by the E.L.M.A. Lighting Service Bureau.

An Ingenious Daylight Sign

Whilst illuminating engineers are constantly occupied in making use of artificial light, the possibilities of daylight are apt to be overlooked. This point is brought to our notice by an ingenious form of sign that has recently been introduced in shop windows. It consists essentially of a horizontal plate of clear glass, equipped with a colour-screen, and an inclined mirror of similar size directed towards the street. When the apparatus is mounted in the window the horizontal portion received strong daylight illumination, and a bright image of it is seen in the mirror. From the other side of the street the sign appears quite striking, shining out from amidst the contents of the window as though it received light from behind. As the brightness of the image (except for the light absorbed by the colour-screen) is substantially the same as that of the sky, it naturally stands out from the contents of the window, which only receive a smaller component of the daylight illumination available. The success of the device naturally renders it desirable that a portion of the sky should be visible from the point where the sign is hung.

The Automobile Headlight

In the March and April issues of *World Power* Mr. L. B. W. Jolley contributes an informative article reviewing the automobile headlight and its supply. The phenomena of optical projection are discussed, with the aid of numerous diagrams, and the importance of a standardized beam emphasized. The vital effect of focussing of the lamp filament on all kinds of anti-dazzle devices is pointed out and it is suggested that laxity in the tolerance of manufacture has prevented and limited the utility of many anti-dazzle inventions introduced. There are sections dealing with front lenses, dazzle and glare, and lamp design, the discussion of the various shapes of filaments being particularly useful. In Part II there is a description of various anti-dazzle devices, a discussion of the road illumination required, and an account of generators. After a brief summary of the legal requirements of various countries, the author concludes by emphasizing the vital importance of adequate street lighting. If all classes of roads were equally well lighted the necessity for powerful headlights would disappear, and things are moving in this direction.

Public Lighting in the City of London

We notice that Lt.-Commander Haydn T. Harrison's recent paper before the Institution of Electrical Engineers contained a complimentary reference to the lighting of main thoroughfares in the City of London, which has frequently been admired by visitors from abroad. Two leading features of this lighting are the general use of central suspension and the retention of long-burning flame arc lamps, which is believed to have been fully justified by results. It may be recalled that the rearrangement of the lighting was undertaken as far back as 1911, when a saving in expenditure of nearly £7,000 per annum was effected. The whole of the work was carried out under the supervision of Capt. W. J. Liberty, the late Superintendent of Public Lighting for the City of London, and, as Mr. Harrison remarked, there is no doubt that it reflects great credit on those responsible for its conception.

Incidentally, we may also mention a pleasing incident—the recent presentation by his colleagues to Captain W. J. Liberty, to mark their appreciation of half a year of official life in connection with the city of London. Mr. W. P. Bicknell, the Principal Clerk, in reviewing Captain Liberty's work, also referred to his work in connection with the Institution of Public Lighting Engineers, and to his efforts in starting the Junior Gas Engineers' Association, of which he was twice President.

Compulsory Lighting of Staircases

Some objection has been taken by local authorities to a clause in the London County Council (General Powers) Bill, which makes the owners of tenement property liable to heavy penalties for insufficiently lighting the staircases of these buildings. In the course of a discussion in the House of Commons, says *Municipal Engineering*, protests were raised against this "interference with property." Mr. Harris, a member of the L.C.C. Housing Committee, stated, however, that the Council had found from experience that it was essential for the staircases to be lighted in order to protect the public and the occupiers, and the second reading of the Bill was passed by a large majority. This insistence of adequate lighting in the interests of safety is a novel and important departure. The question of a satisfactory definition of adequate lighting of staircases will doubtless arise.

Demonstrations of Highway Lighting

A recent contribution by Mr. F. C. Taylor to *The Electrical World* describes a highway lighting demonstration on the Buffalo highway, extending from Canandaigua to Bloomfield, which is regarded as a main artery of traffic. Several alternative systems were shown, and ultimately fittings utilizing 400-candle-power frosted lamps on 10-ft. cranes on poles spaced 250 feet apart were adopted. One point debated was the choice between general and bilateral distribution—the latter involving concentration of light mainly along the highway by what, in this country, is often termed "longitudinal lighting." The selection of a general system was decided largely by the consideration that the light afforded sideways at crossings and side-roads, and to the farm-houses lining the route, was fulfilling a useful purpose. Several farmers expressed their appreciation of the protective value of the lighting, as thieves would now hesitate about approaching the house by a lighted road. It was also considered that the lighting added considerably to the value of the property. One farmer stated that he had owned his farm for seven years, but had not received an offer for it until the lights were turned on. The height of the lamps from the roadway is approximately 18 ft. 6 in. Nevertheless, great importance was attached to the use of frosted lamps, as it was considered that this diminished the glare materially; even with 200-candle-power bare lamps the glare was quite distressing. The absence of glare and good illumination at the sides of the road is considered a good feature by motorists. It has also been found that the installation of this highway lighting has greatly diminished the troublesome glare from headlights. On the highway without illumination the headlights were blinding, but with adequate illumination the light background reduces the contrast with the brightness of the headlights, and their effect is much less noticeable.

The Use of the Integrating Sphere for Gas Lamps

Whilst the integrating sphere has proved invaluable for determining the mean spherical candle-power of electric incandescent lamps, its application to gas lamps (and, to a limited extent, open-type arc lamps) is more difficult. In the former case the chief trouble is the question of removing products of combustion and the doubt whether an incandescent gas lamp is functioning normally in the confined space. In his address to the German Illuminating Engineering Society last year Dr. L. Bloch remarked that the sphere has found little application for lamps of this description. This comment has led to an interesting communication to *Licht und Lampe* by Prof. J. M. Verff, who describes experience with an integrating sphere in Utrecht in 1924. For testing gas lamps of moderate power a sphere 1½ metres in diameter was found sufficient. Special ventilating methods are necessary. If the sphere is completely closed the products of combustion first rise and then fall, and measurements showed that after five or ten minutes a diminution in the recorded candle-power began. A measurement could, however, be made in one minute, after which fresh air was admitted. These experiments apparently related to lamps of relatively low candle-power and consumption. It seems doubtful whether powerful high-pressure lamps could be so tested without very special arrangements for the ventilation being made.

The Japanese Illuminating Engineering Society

Two recent numbers of the *Transactions* of the Illuminating Engineering Society in Japan have reached us. We are glad to see that it is now becoming usual for abstracts of original papers in English to be included. This applies, for instance, to the papers by Mr. Ziro Yamauti on the calculation of interior illumination and by Mr. M. Igari on the relation between efficiency and life of the tungsten lamp. We also notice a study of distribution of temperature on the surfaces of bulbs of incandescent lamps by Messrs. M. Horioka, T. Sato and K. Yamamoto, and a note by Mr. L. Honjah on spherical reduction factors.

"Light-Architecture"

Under this title an exceptionally interesting paper was recently read by Prof. Dr. J. Teichmüller before the Austrian Illuminating Engineering Society. This new word was used by the author for the first time at the recent "Gesolei" Exhibition in Düsseldorf; it is intended to convey the use of light to reveal architecture and produce pleasing and decorative effects. In the reproduction of the paper, which has appeared in *Die Lichttechnik*, many striking examples of the use of light in this way are shown. We may mention particularly the devices utilizing architectural features, such as recesses in walls, cornices, pillars, etc., and there are also some photographs showing the effect of the inclination of rays on the appearance of carving and stone projections.

The Nela Lighting Research Laboratory: Recent Researches

We have received from the Nela Research Laboratory (Cleveland, U.S.A.) reprints of a series of papers recently presented before various bodies. Amongst communications to the Illuminating Engineering Society (U.S.A.) we note a list of research problems which would certainly furnish work for many years to come, and a paper by Mr. M. Luckiesh entitled "Contributions of Science to the Lighting Art." Physiological and psychological researches are strongly represented. Contributions of Dr. Percy W. Cobb deal with the speed of retinal impression and the effect of field brightness thereon, and "Light in the Industries," whilst reprints from the Journal of the Optical Society of America include Mr. L. L. Holladay's researches on glare and visibility. The activities of the Nela Lighting Research Laboratory are summarized in a well-got-up little pamphlet, and cover a wide range. Finally, we have to note a list of books and articles written by Mr. M. Luckiesh himself. Fifteen books and over 200 miscellaneous articles are mentioned—an illustration of the industry and versatile knowledge of the author who, in this country, is best known for his numerous works on colour problems.

TECHNICAL SECTION

COMPRISING

Transactions of The Illuminating Engineering Society and Special Articles

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

Artificial Light as an Aid to Aerial Navigation

By H. N. GREEN (Royal Aircraft Establishment, Farnborough)

(Proceedings at the Meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts, 18, John Street, Adelphi, London, W.C., at 6-30 p.m., on Tuesday, February 22nd, 1927.

(Continued from page 101, April, 1927.)

Lighting of Croydon-Lympne Air Route.—I will now pass on to some examples of modern practice as exemplified by the beacons and location lights on the London-Paris route between Croydon and Lympne aerodromes. Fig. 9 shows a map of the country on which are marked the positions of the various beacons. The small circles represent their medium-weather ranges in miles, and it will be noticed that the condition is fulfilled that at least one beacon should always be visible.

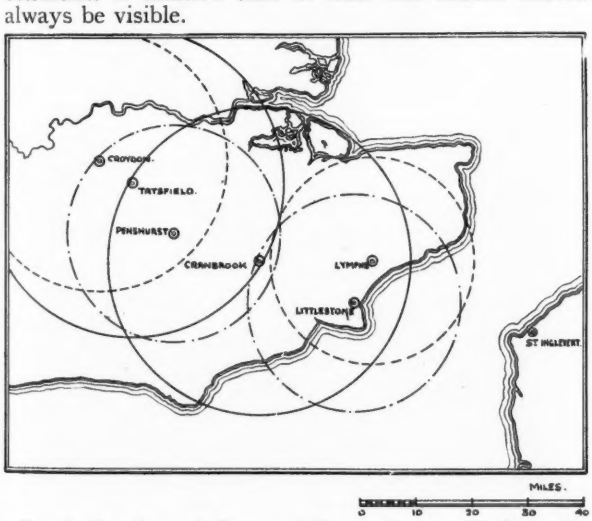


FIG. 9.—Location and Ranges of Beacons between Croydon and Lympne.

In addition to the guidance afforded by the six beacons shown, a pilot who knows the course obtains considerable assistance from other lights not primarily intended to aid aerial navigation. As examples, the lights of Croydon have a very characteristic shape, and the Crystal Palace is usually visible. Following the railway from Croydon to Ashford, the lights of Tunbridge Wells and Tonbridge are easily recognizable on either side. Arriving at Lympne the lights of Hythe and Folkestone are seen. White lights of this description are helpful to an experienced pilot; one strange to the route is more liable to be confused.

The beacon erected at Croydon terminal aerodrome is of the neon tube type. It was installed temporarily for experimental purposes, and became a permanent institution. The beacon consists of sixteen 20 ft. neon tubes, 30 mm. diameter, connected in groups of four in series. Current is taken from the aerodrome supply at 200 volts 50 cycles A.C., and stepped up to 5,500 volts. The power required to operate the beacon is 8 kw., and the total horizontal candle-power approximately 13,700. Flashing mechanism is included on the low-tension side, and the beacon has a character consisting of a 1-second flash followed by a 1-second eclipse.

The light is so distinctive in colour and appearance that it is perhaps hardly fair to say that it cannot be seen till it has a visibility of 1.5. The official range is given as 45 miles, but I am told that in clear weather the light has been seen from the French side of the Channel by pilots leaving St. Inglevert. The colour of the light, as you probably know, is intermediate between red and pink.

It is claimed for neon light, and for red light generally, that it has a greater range in fog than white light. This statement is perhaps made oftener than definite figures are produced to support it, and at present we have an open mind as to how valuable this property really is. We have found, however, that in fog the red glow shown by the beacon is a useful landmark, even when the neon tubes are themselves invisible.

The lights marking the airway between Croydon and Lympne are of the automatic unattended gas type. Each light is equipped to function for a period of six months without human attention.

The main route lights are situated at Cranbrook, Kent, and near Tatsfield, Surrey. They are placed upon natural elevations of approximately 600 and 800 feet above the sea level; the lights are carried on steel towers of the braced pier type, and are of such a height that the focal plane is above all surrounding trees.

Acetylene gas in a dissolved form is contained in accumulators

FIG. 10.- Tatsfield Beacon.

housed in the base of the lighthouse tower. From the accumulators the gas is conveyed to the apparatus installed in the lantern house, where it first enters a pressure regulator in which the high and naturally varying pressure of the gas is reduced to the constant low pressure at which the apparatus is designed to work. From the pressure regulator the low-pressure gas passes into an apparatus known as the aspirator, where by a system of diaphragms and valves, actuated by the incoming gas, air and gas are mixed in the correct proportions to ensure perfect combustion at the burner.

Upon each stroke of the aspirator the mixture of gas and air resulting from the previous pulsation is forced through a discharge valve to an "equalizer," where a sufficient volume of gas is accumulated to maintain a steady supply to the burner.

The incandescent acetylene burner is of the inverted type, and the mantles employed are made of a special silk fibre suitably impregnated. They incandesce to an extremely high degree of brightness, approximately 250 candle-power per square inch, and are nearly spherical in shape.

In order to guard against the light being extinguished by mantle failure an automatic exchanging gear is fitted carrying a number of spare mantles, which are used in succession. When a mantle in service becomes defective the gas flame escaping through the fracture impinges upon and destroys a fusible catch. The fusing of this catch releases a spring whereby the mechanism is caused to rotate, the faulty mantle is lowered away from the burner and the next mantle for service is automatically placed in position, becoming fully incandescent in from 15 to 20 seconds.

The average life of a mantle is several months, and a sufficient number is carried on the exchanging gear to ensure continuity of service during a period of six months or more, after allowing for all contingencies.

The optics employed in both the Tatsfield and Cranbrook lights are of the revolving type, having a focal distance of 375 mm. (Fig. 11.) Each comprises six panels, and the light character produced is two groups of three flashes, with a short eclipse of half a second between flashes and a long eclipse of 5.7 seconds between groups. The duration of each flash is one-tenth second. Cranbrook light exhibits two groups of three white flashes, and at Tatsfield the centre panels are at present fitted with red filters, producing a character of white flash, red flash, white flash, in each group. Each panel is fitted with prismatic elements and mirrors to obtain the required vertical light distribution. The intensity in the main beam from each panel is approximately 90,000 candle-power. The light source employed is an incandescent mantle of 35 litres capacity, giving 175 horizontal candle-power. The lenticular apparatus is carried upon a table mounted on ball bearings, and is caused to revolve solely by the pressure of the gas passing to the burner. The movement of the diaphragms of the aspirator is used for this purpose, their reciprocations being converted to a rotary motion by means of a simple system of levers.

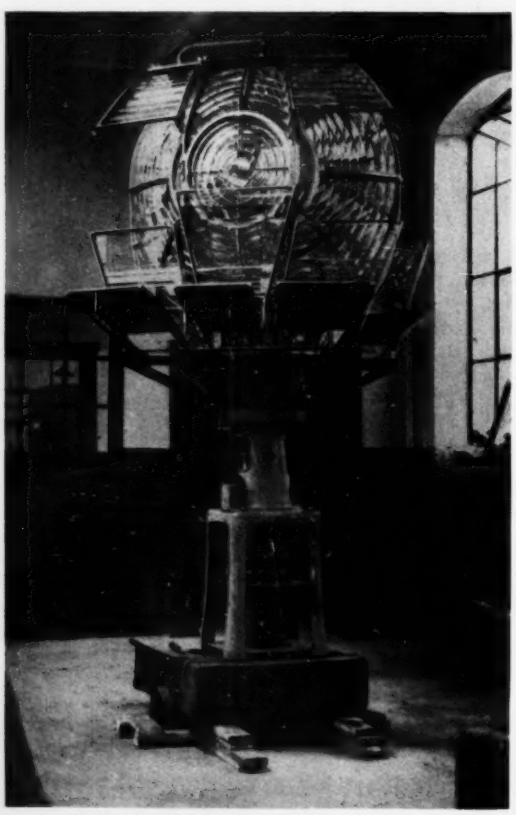


FIG. 11.—Optical System of Tatsfield Beacon.

FIG. 12.—Location Light for Emergency Landing Grounds.

Perhaps the most interesting feature of the equipment is the "light valve," whereby the burner is automatically lit and extinguished. This piece of apparatus consists of a number of bright rods surrounding a central rod coated with lampblack. In the dark all the rods are affected equally by temperature changes, but in the presence of light the red or heat rays are reflected by the bright rods but absorbed by the black one, which consequently assumes a slightly higher temperature.

The differential expansion of the combination is sufficient to actuate a small valve which controls the main gas supply, a pilot burner being, of course, kept continually alight, and the instrument can be so finely set as to ensure the lighthouse being brought automatically into operation in dark, foggy, or cloudy weather, irrespective of the time of day.

At Penshurst and Littlestone emergency landing grounds, beacons of lower power are installed. These "location" lights are identical in all respects with the route lights at Tatsfield and Cranbrook, so far as the lighting apparatus is concerned, but the incandescent burners are of 25 litres capacity, and the lenses are of

the fifth order revolving type, producing a double-flash character. Each lens is composed of four panels, so arranged as to give a short eclipse of 0.35 of a second between flashes and 5.8 seconds eclipse between groups. The intensity of light projected through each panel is approximately 13,500 candle-power. (Fig. 12.)

These units are housed in lanterns without towers, the focal plane being approximately 10 feet above ground level.

Lympne aerodrome is equipped at present with a cone light of the type originally installed at Croydon, which was fully described in Col. Blandy's paper.

Aerodrome Illumination.—Another matter which deserves detailed treatment is in regard to the provision of illumination to facilitate the landing of a machine at the end of its journey. On arrival at the aerodrome, after receiving permission to land, the pilot requires to know the direction of the wind, the position of the aerodrome boundaries, and last, but not least, the whereabouts of the ground. A knowledge of wind direction is essential, as a landing should always be made into the wind. Landing with an air speed of 70 miles per hour against a 30 miles per hour wind, the aeroplane will touch ground at 40 miles per hour (70 – 30). Landing with the same wind, the machine touches the ground at 100 miles per hour (70 + 30).

FIG. 13.—Landing Lights at Farnborough Aerodrome.

At aerodromes where an electric supply is available wind direction is given by means of lights sunk in the ground. 100-watt gasfilled lamps are used, in heavy cast-iron boxes, covered with thick glass and sunk flush with the ground surface. A number of these lights (24 are installed at Croydon) are arranged so that the letter L can be shown in any one of several directions, the short arm of the L, consisting of one light, being at that end of the L which points into the wind. The long arm of the L consists of five lights spread over a distance of 900 feet, and is always placed on a level stretch of the aerodrome, which is free from obstructions. The pilot can thus see at a glance where and in which direction he should come down. (Fig. 13.)

At emergency landing grounds, where neither an electric supply nor personnel for operating the lights is available, an automatic indicator is used. The general design of these units, which are installed at Penshurst and Littlestone, is shown in Fig. 14. They comprise a whitened vane-structure in the form of the letter T, the tail member being rather over 20 feet in length. The vanes are mounted flat upon a vertical axis, and are free to rotate. The head of the T is kept into the wind by a vertical fin placed along the centre of the long member.

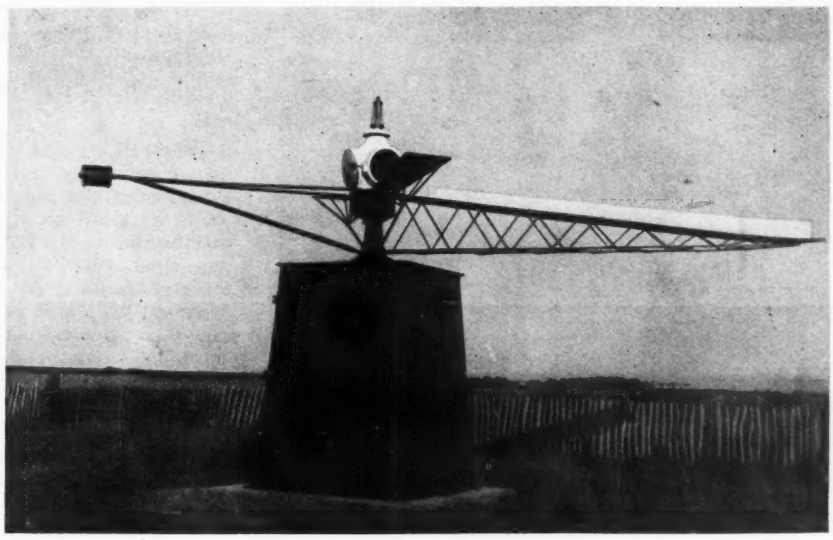


FIG. 14.—Automatic Wind Indicator.

The lantern, placed at the junction of the vanes, is equipped with three dioptric lenses arranged to project a beam of light of small divergence along the upper surface of each vane. An automatic mantle-exchanging device and light valve are installed, and the light is given a character by causing it to give a one-second flash every two seconds. As a flashing light of indeterminate shape, the indicator has a 7 to 8 mile range, whilst it is clearly visible as a distinct "T" by day and night at a range of 2 to 3 miles.

The boundaries of the aerodromes at Croydon, Penshurst, Littlestone, and Lympne are marked by small self-contained gas units of the type shown in Fig. 15. They are placed round the landing area and indicate its limits. These lights are fitted with burners of the "open type," in which pure acetylene gas is consumed without first being mixed with air. The burners are of 15 litres capacity, and a rapid-flashing red-light character is given (90 flashes per minute). The optical apparatus employed is of the fixed type, the light being visible through 360° in azimuth and approximately 180° in the vertical plane. Light is projected along the horizontal and to 12° above through the dioptric drum lens, and higher elevations are dealt with by a prismatic refractor. The number and duration of flashes occurring in any given period of time is capable of being very widely varied. With the flashing character at present used sufficient gas can be stored in the pedestal carrying the optic for six months' unattended service. The apparatus just described gives an incoming pilot wind direction, the position of the landing course and

FIG. 15.—Boundary Light.

FIG. 16.—180° Aerodrome Floodlight.

of the aerodrome boundaries. All that is now required is to be able to see the ground for the actual process of landing.

A very satisfactory method of floodlighting the aerodrome has been found, and it is now almost as easy to land by night as by day. Fig. 16 shows the floodlight used. It consists essentially of a third order drum lens (focal length 500 mm.) equipped with a high-intensity arc lamp giving, without the aid of the lens, approximately 70,000 candle-power.

The complete unit is mounted on a trolley so that it can be moved to that part of the aerodrome from which the direction of the light will be correct for the prevailing wind at the time. The centre of the lens is raised from three to four feet above ground level, and when in position the lens is tilted, by means of the levelling screws on the housing, to illuminate as large an area as possible.

The beam from the lens has a vertical divergence of about 1½°, and a horizontal divergence of 180°. The area, which is comfortably illuminated for landing purposes, has a radius of 1,500 feet from the floodlight as centre, and is semi-circular in shape. The beam intensity is of the order of 850,000 candles. It might be expected that a light of this power would be liable to dazzle the pilot, but the lens is so accurately made and the light so closely confined to the beam that its position would scarcely be noticeable from the air were it not for the ground illumination.

Fig. 17 is a picture of part of Farnborough aerodrome taken by the light of the floodlight; only a portion of the total area illuminated is taken in by the camera.

The small white target in the middle of the photograph is a piece of millboard two feet square. The sharp shadow thrown behind the target, which was 1,000 feet from the floodlight, should be particularly noticed. The light in the immediate neighbourhood of the lens all comes from the arc flame. This is above the focal point, and the light is therefore thrown downwards, making the beam divergence appear larger than it really is.

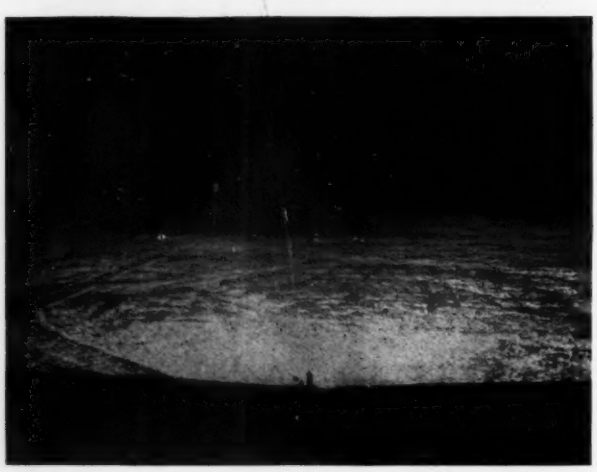


FIG. 17.—Farnborough Aerodrome illuminated by 180° Floodlight.

When in use the floodlight is stationed on the aerodrome boundary, pointing directly into the wind. The aeroplane comes in over it on the left-hand side. Most pilots look out for the ground over the left side of the machine when landing small aeroplanes; on commercial passenger types the view is generally restricted to forward and the left; therefore, when landing in this direction the light is always out of sight, and glare can only come from reflections on the machine, as, for example, from the wind screen. These reflected glare effects are not serious, as by the time they occur the pilot has flattened out for the final glide, and the machine is a few feet from the ground.

Shadows of the machine on the ground are not troublesome—they are not even noticeable. The beam is very nearly parallel to the ground, and the shadow is therefore thrown far ahead.

Flying in Fog.—I will now touch on what is, from the point of view of lighting, an entirely different aspect of the subject—that of flying in fog. An aeroplane can take off, fly and land in almost any wind or weather; but dense fog, as, for example, when the ground visibility is 30 to 50 yards, is troublesome. Obviously difficulties arise in landing a machine at 80 miles an hour under conditions where you would hesitate to drive a car at eight. Flying is not at present attempted when visibility is abnormally bad, but the possibility exists that a machine may go up in moderate weather and get caught in fog, and our present aim is to devise apparatus to deal with such an emergency. I shall be obliged to digress slightly in explaining the chain of operations by means of which a machine will be brought safely to the aerodrome.

When flying on the London-Paris airway a pilot can at any time receive his bearings by wireless telephony, with sufficient accuracy for him to be able to fly to the vicinity of the aerodrome. The next stage of the journey will have to be accomplished by means of what is known as a "leader" cable. This consists of a loop of cable, one of the straight sides of which runs through the aerodrome. The cable carries a low-frequency current, and on the aeroplane is mounted a detecting instrument which, from the intensity and angle of the magnetic field surrounding the leader cable, gives the pilot a visual indication of his height and position relatively to the cable.

Once the instrument picks up the magnetic field and begins to give directions the pilot can make for the cable, get on the track formed by the loop, and fly round it coming lower and lower. Near the straight length of cable crossing the aerodrome is a small loop operated with an alternating current of different frequency. This gives the pilot an indication of when he is over the aerodrome, and he then comes down as low as possible. The final landing is done by means of light.

The lights employed will probably consist of neon tubes laid horizontally at intervals down the landing course. They will be suitably protected in cast-iron boxes embedded in concrete, covered with thick plate-glass and laid flush with the ground. Observations were made last winter from a captive balloon at Croydon aerodrome on a neon ground installation of this type. It was found that the tubes were very distinctive and clearly marked the landing course. On a foggy night, when the ground visibility was 80 yards, the neon tubes were visible (as tubes) at a distance of 200 yards. With the leader cable system it is expected that difficulty will be experienced in keeping to the track when at low altitudes, and the instrument will probably be arranged to give indications down to 50 feet. This will enable the pilot to land on the line of neon lights, which are visible under the worst conditions when vertically above them.

I have described the general scheme, but it is not yet in operation as a whole. Directional wireless is in every-

day use, the leader cable is being developed at Farnborough, and an experimental installation gives very promising results,† while the tests at Croydon have given us a good idea of the possibilities of neon tubes. During the balloon tests ascents were made at night with ground visibility 30 to 40 yards and fog up to 1,200 feet. When well above the fog, in clear moonlight, a large red pool of light could be seen on the fog surface, which would have been visible from a considerable distance to an airman flying at from 5,000 to 10,000 feet.

In daylight-fog the use of artificial light to mark an aerodrome seems out of the question. The reflected sunlight from the fog surface makes it quite impossible to see anything through it. At night, however, coloured light may be used to illuminate the fog surface and indicate the position of an aerodrome.

Another interesting observation made during the fog was that the neon tubes were often visible from the ground; they disappeared some time after the balloon started to ascend and reappeared when well above the fog. (Fig. 18.)

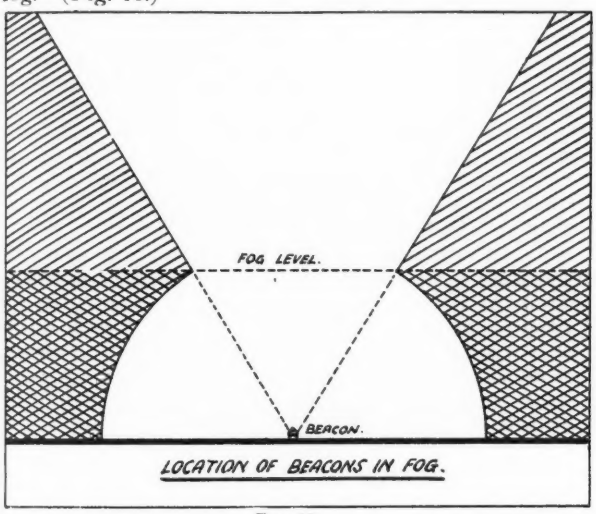


FIG. 18.

If the fog is assumed to be uniform in density and to extend upwards, say 200 yards, then a light which is visible in the fog at 220 yards on the ground will be visible anywhere within a hemisphere in the fog having a radius of 220 yards. Above the fog level the light will be visible within a cone having its apex at the light. It follows that to locate ground lights is easiest when flying at the maximum possible height. I think most pilots would instinctively fly near the fog surface, so as to be as close as possible to the lights they are trying to see. We have so far been unable to obtain any definite information as to the average density gradient of fogs, but the point seems to be one worth establishing.

I hope I have been able to give you some idea of the numerous problems with which we are faced, and the lines of development we are following in their solution. There is relatively little past experience to help us, but we are gradually establishing the first principles and working to improve methods of applying them.

In conclusion, I have to thank the Air Ministry for permission to read this paper, Mr. Toulmin Smith for advice and help in its preparation, and Messrs. Chance Bros., the Gas Accumulator Co., and the General Electric Co. for the loan of exhibits and photographs.

Discussion

CAPTAIN L. E. RICHARD (Chief Aerial Transport Officer, Croydon Aerodrome), in opening the discussion, said that the subject of the paper was one in which he was extremely interested. He felt that he had learned a good deal from the paper. The author had referred particularly to the difficulties imposed by fog. At Croydon Aerodrome difficulty was often experienced in landing during very foggy weather, and he would, therefore, welcome anything that could be done towards the solution of this problem.

Since the meeting I have thought of several points which may be of interest:

(1) Some pilots regularly flying from this aerodrome definitely prefer the rotating floodlight to the neon beacon as a location light for finding the aerodrome in foggy weather. Apparently this is accounted for by the fact that even in thick fog the strong light from the floodlight, when rotating, catches their eye quicker than the neon beacon. This would suggest that the neon beacon, with mirrors and a rotating mechanism, might be an improvement on either.

(2) I have heard that the Germans are using a very effective form of mist-piercing flare, which is carried on a man's back to any part of the aerodrome. Apparently the light produced is of a strontium colour, and our pilots say that it is the best thing they have seen when trying to locate an aerodrome in foggy weather. I also understand that they have on occasions placed these men with their flares in the form of a landing "L" on the aerodrome.

Mr. A. K. TOULMIN SMITH said that he took a great interest in the subject of the paper, at which he had been working for many years. The author had dealt with the important question of the speed of signals, and had shown the difficulty in obtaining rapid signals from beacons, especially when high-power gasfilled lamps were used as the source of light and the signalling was effected by lighting up and extinguishing these lamps. The importance of making the time occupied for a signal as short as possible had been forcibly brought home to him (the speaker) during a night flight between Croydon and Lympne. A very deep and dense bank of cloud had been encountered near Tonbridge. It was decided to fly above the cloud, and the machine climbed to about 8,000 feet and proceeded towards Lympne. He noticed that although glimpses of lights on the ground could occasionally be caught through gaps in the clouds, the time was so short that it was generally impossible to recognize signals. Afterwards, on descending below the clouds, they ran into banks of mist, when visibility was as low as half a mile. Again it was exceedingly difficult to recognize the character of the lights owing to the short periods during which they were within range.

The question of light distribution had been dealt with in the paper. This was likewise a matter of importance. During range tests with the first revolving beacon erected at Croydon it was found that, although the light could be seen at 27 miles range, it entirely disappeared at a distance of seven miles, and reappeared again at a shorter range. Investigation showed that this was due to incorrect distribution of light, the disappearance being occasioned by too great a fall in light intensity while passing from one part of the beam into the next. This incident illustrated the importance of accuracy in determining a correct light distribution in beacons.

Mr. J. R. WHARTON (Messrs. Chance Bros. & Co.) also congratulated Mr. Green on his excellent paper. The subject was a big one, but Mr. Green had dealt with the essential points in a very clear and concise manner. He noticed that the author had not referred to ordinary marine lights, in which he (Mr. Wharton) was naturally interested, as his firm had been concerned with the design of such lights for about 80 years. He believed that some of these, such as, for instance, the South Foreland light and the light on the Admiralty Pier at Dover, were of considerable service to pilots. He would be glad to receive any information as to the use made of such lights, and especially how *near* they are seen from the air.

He had been interested to note that the character of the light at Tatsfield had been altered by making the centre flash of the three flashes red. Had this been done by merely putting a coloured screen in front of the panel? As the panels were originally intended to give equal intensity for the three white beams, one would expect that at considerable distances the two white flashes would be seen before the red, thus altering the character of the light. Could Mr. Green give any information as to this?

† Flt.-Lieut. Cooch. *Journal of the Royal Aeronautical Society*, Vol. XXX, June, 1926.

The author had implied that it was not possible to get a Morse code letter with the revolving type of optical apparatus. With the standard type this could not be readily done, but it was quite possible to design a revolving lens to do it, which would not need to be of a more complicated type than many of those round the coast of the British Isles.

He quite agreed with Mr. Green's somewhat cautious reference to the penetrating effect of red light in mist and fog. He believed that some people held the impression that fog penetration could be increased by putting a red or yellow screen in front of a white light Clearly this step would only diminish the power of the light, and therefore the power of fog penetration could not be increased. On the other hand, there was considerable value in the distinctive quality of colour, which might enable a red light to be recognized when everything was blurred.

He noticed that the candle-power given for the neon light and for the Penshurst beacon happened to be the same, viz., about 13,000 candles, and asked if Mr. Green could give the respective ranges at which these have been seen. It would be interesting to learn this, thus getting a comparison between a white light of small area and a red light of large area. In this connection, he would like to say that a very prominent lighthouse engineer held that of two lights of equal candle-power, but different size, the larger would be seen further, especially in misty weather—e.g., if a lens 2 ft. square, giving, say, 10,000 candle-power, were tested against a lens 4 ft. square giving the same candle-power, the latter would be seen considerably further.

CAPTAIN TOULMIN-SMITH suggested that the ideal time in which a character should be given was as short as three seconds.

Mr. WHARTON said he quite understood the necessity of this, from what both Captain Toulmin-Smith and Mr. Green had said, but would suggest that in this case the short flash in a Morse code letter would be very short indeed, and he would like an idea of the low limit of length which is considered desirable.

Mr. D. DIXON emphasized the value of the revolving beam, not only in rendering a light more distinctive, but in making it more readily visible. When a revolving light was shining at right angles to one's course, one could see the reflected light in the sky before the source itself was visible. He had observed that, in general, one saw first the expanse of lighted area at sea. He would like to mention the transmission of sound signals in the sea originally used, he believed, in submarine chasing. This enabled an object at some distance, such as a submarine or rock, to be located by the reception of the echo in the receiver. It seemed possible that the system might have some utility for aerial navigation in a fog. Mr. Green had referred to the value to the pilot of recognizable systems of lights, such as those of towns near the route. Possibly the co-operation of municipal authorities might be obtained in arranging town lighting, partly with a view to rendering assistance to pilots.

Mr. G. P. GARBETT expressed his interest in Mr. Green's able paper. He had come to the meeting as a student, but he would like to show one piece of apparatus that might be of interest, namely, a type of light that had been installed every five miles on the airway between Berlin and Cologne. Mr. Garbett then gave a description of this apparatus, which was demonstrated at the meeting.

This apparatus consisted of a glass tube 22 mm. in diameter and approximately 2 metres in length, the glass being bent in special formation and mounted on a cast-iron base of hollow formation; the tubes being charged with neon gas, through which high-tension current was discharged through the medium of a transformer contained in the hollow case forming the base of the sign.

Mr. Garbett added that units of this type were now being investigated by the Air Ministry. He thought that there was something inherent in this neon type of light which rendered it particularly suitable as an aid to aerial navigation.

PROFESSOR J. T. MACGREGOR-MORRIS congratulated the author on his excellent paper. Having taken a keen interest for a number of years in the subject of marine lighthouses, he had found this paper particularly interesting. He wished to draw attention to the following passage in the paper: "It has been shown by Paterson and Dudding that the visibility of a point source is proportional to the total candle-power of the source, and is independent of intrinsic brilliancy." Is this true for neon lamps, or is there some other factor entering in, dependent, perhaps, on the spectrum of the source? Also, he would like to enquire whether an alternation of a red light and a green light had been tried. It seemed possible that such an alternation of coloured lights would give a result that was even more recognizable than an alternation in intensity.

Mr. L. HALL said that he understood that a test of the beacon at Farnborough had recently been made. If he recollected rightly, there were three beams suspended vertically, one above the other, flashing intermittently. It would be interesting if Mr. Green could give any particulars of the test and the conclusions arrived at. He had been struck by the fact that the penetrating effect of the neon beacon at Croydon was very much greater than would have been anticipated from observations of signs in use in the streets. This seemed to be the result of the special shape and design. He understood that the lights at Croydon, marking the boundaries of the aerodrome, were flashed both by night and by day, and were not controlled by a light valve. If this was so, it would be interesting to know the reason. With regard to lights based on variation in colour, he doubted very much whether pilots would welcome any system which depended on picking out different colours.

CAPTAIN TYMMS remarked that in lighting an airway it seemed to be assumed that it was desirable to have a string of lights more or less close together. On the Hanover-Berlin route the lights were placed at distances of five miles, and the same system had been followed in America. In some cases lights were placed as close together as three kilometres; but, after all, the basis of navigation was the mariner's compass. If aviators had to have a perfectly continuous view of the ground or beacons in order to get from one place to another, aerial transport would not, he thought, advance very far. The difficulties of such navigation were always much exaggerated. There was a disposition to think that lights were the only guide in night travel. The methods of navigation used at sea had to be taken into consideration and used in their proper place. For extensive routes the cost of such elaborate lighting would be prohibitive. There was no doubt that from many standpoints the neon light was the best. In the neon beacon they had a source of light with good fog-penetrating properties. He thought that this had been proved by tests at Croydon. He was not at all sure that the solution of the problem might not ultimately be found in the use of the rays outside the visible region of the spectrum; this, however, was a question for the illuminating engineers to consider.

The double-L system which Mr. Green had described had been abolished as an international measure by the International Commission for Air Navigation because it was too expensive, and a system of three lights in the form of an isosceles triangle substituted.

The paper was a very valuable one, and he was very glad that the Society was taking an interest in problems which, in the interests of progress in aviation, it was of vital importance to solve.

LIEUT.-COL. C. H. SILVESTER EVANS remarked that some of the calculations involved a knowledge of the transmission coefficient. He would like to ask (a) What is the average coefficient of transmission of the lenses employed? and (b) How and where were the atmospheric transmission coefficients (used to calculate the range curves) obtained? The information available on atmospheric transmission is distinctly meagre, and Mr. Green's paper serves once again to emphasize the point. At high altitudes, as Mr. Green said, one could only assume the factor, but there was good reason to suppose that the coefficient of atmospheric transmission at high altitudes might closely approach unity if solid matter and water vapour were the chief causes of

the absorption. Meteorological data established from *ballons sondes* and pilot balloons the height at which solid matter and water vapour were present in the troposphere (he hesitated, even with rapid advance in aerial traffic, to consider the stratosphere)! Even now, however, definite data up to at least 15,000 feet were required, and to obtain this a costly and lengthy process was necessary.

MAJOR MCALPINE, in expressing his appreciation of the high quality of the paper, urged the Society to devote attention to obtaining sources of light for aerial navigation of sufficient power; at present it had been found necessary to go abroad to obtain the desired conditions.

Mr. A. G. WATSON said that experience with the existing neon beacon at Croydon undoubtedly proved that neon had some characteristic which is of considerable value for getting light through atmosphere which limited the visibility of ordinary white light.

It appeared that few experiments had been conducted with the object of ascertaining whether it was not possible to find a better arrangement of tubes than that at Croydon. It was his conviction that area played an extremely important part in determining the distance at which beacons could be seen, and as an example he cited the "Cone Light," which, when first erected at Croydon, was seen from an airship as a triangle of light at a distance of 23 miles. This unit was 25 feet in diameter at its base, and approximately 15 feet high. It was illuminated by four 1,500-watt gasfilled lamps arranged 90° apart round its summit. Having regard to the relatively very low degree of surface illumination then available, and the great range of visibility obtained, he would suggest that experiments should be conducted with the tubes arranged in various forms.

The neon beacon at Croydon, it was believed, was erected in its existing form mainly because that happened to be a convenient one to undertake at the time, and it certainly seemed desirable to go further into the question. He suggested that the tubes might be arranged radially—like a fan—the sign subtending, say 180°, and the whole mounted in such a manner as to easily be turned about a vertical and horizontal axis, as occasion demanded. In this way the maximum available luminous flux might be made available to an aviator approaching the beacon.

Referring to a remark by a previous speaker that variations of character could be obtained by, for example, dividing the panels of the existing optics at Tatsfield and Cranbrook, and fitting between them sections of a first-order lens of the fixed type, it appeared that that speaker had overlooked the difference in light intensity which must result, and also the still more important point of the duration of the flash.

The CHAIRMAN (Mr. J. W. T. WALSH) said that he had read the paper very carefully, and was struck by the extraordinary amount of information which it contained, and the interesting way in which that information was conveyed. He was sure that it would serve as a permanent source of information for all concerned with aerial light beacons.

Optical projection problems always attracted him, and there were one or two points in the paper to which he would like to refer. He wished particularly to refer to the formula given by the author for the angle of divergence of the beam which came from the outer elements of the dioptric lens. He thought that the effects of refraction were not fully taken into consideration. The lenses were dioptric, and not catadioptric, so that the bending of rays was considerable. Hence he thought that the beams from these outer elements were more divergent than the formula suggested.

He also took exception to the author's brief reference to the "disc" source of light. With a disc source the divergence of the beams which derived their light from the oblique rays was usually very small. He thought that if the author examined this problem with the same detail as that devoted to a spherical source he would find that the formula needed correction.

With regard to calculations of candle-power, directly one departed from the axis of the lens system matters became complicated. It was of considerable importance to know how the candle-power fell off two or three degrees away from the axis.

The question of the duration of the flash also interested him. One speaker had pointed out that with a total period of only three seconds some of the individual flashes would have to be exceedingly short. No doubt the author was aware of the work done some years ago on the visibility of very short flashes. It had been shown that below a certain limit of duration of flash the visibility distinctly diminished. Below a certain limit the visibility was proportional to the duration of the flash.

Mr. H. N. GREEN, in reply, said:—

Captain L. E. Richard mentioned that some pilots prefer the rotating floodlight* to the neon beacon for finding the aerodrome in foggy weather. This is undoubtedly due to the high intensity of the floodlight (850,000 candle-power) as compared with the neon beacon (13,700 candle-power).

The suggestion to equip the neon beacon with mirrors and a rotating mechanism is open to two objections. Firstly, neon tubes, owing to their length and low intrinsic brilliancy, are not readily adaptable for use with mirrors. Secondly, assuming mirrors and a rotating mechanism were fitted, then the neon beacon would fall into the same class as the rotating lens, and would have almost the same limitations as regards flashing character.

Mr. J. R. Wharton raised the question of the utility of marine lights. These are of considerable assistance to pilots, and the unmasking of certain lighthouses on the land side is under consideration.

As regards the "nearness" at which a marine lighthouse can be seen, this will probably depend on beam candle-power and atmospheric conditions.

The Cape Gris-nez lighthouse is visible on a clear night when flying over London, and the beam is still visible by diffusion when approaching and flying immediately over the lighthouse itself. In bad visibility a lighthouse would probably not be seen again after flying through the main beam.

The character of Tatsfield light has been altered by colouring the centre flash by means of a red filter. As Mr. Wharton anticipates, the two white flashes become visible before the red flash. Sufficient data has not yet been collected to give relative ranges.

It is not possible to compare Penshurst location light and the neon beacon on an equal candle-power basis. The figure of 13,500 given for the Penshurst light refers to each panel of the lens, before the light has been spread in the vertical plane by the refracting prisms and mirrors.

The opinion that a large source is visible at longer ranges than a small source of equal candle-power is not supported by the work of Paterson and Dudding. It appears, however, that a large source is more easily recognizable (as distinct from visible) from the air than a small one, even though both have the same visibility.

The minimum period allowed for a flash in the case of revolving beacons is one-tenth of a second. If this period is not exceeded it is possible to exhibit any of the letters of the Morse alphabet, allowing a reasonable period of eclipse between signals, within a total period of three seconds.

Mr. D. Dixon suggested the use of sound bearings to assist navigation in fog. The volume and variety of sounds emitted by the aeroplane itself make the application of this method difficult, if not impossible.

Mr. L. Hall referred to a three-light beacon undergoing tests at Farnborough. This is an experimental model on which trials have not yet been completed. The beacon in regular use at Farnborough is the converted strontium beacon. The boundary lights at Croydon,

* The rotating floodlight consists of the 180° aerodrome floodlight, so arranged that the lens can be given an upward tilt and rotated about its vertical axis. Normally the floodlight is used for landing purposes only, the rotating mechanism having been added to convert the floodlight into a stand-by beacon for use in the event of a breakdown of the neon beacon at Croydon.

and at all other aerodromes on the route, are in continuous operation. It has been found more economical to leave the lights burning than to fit either automatic or hand control. The amount of acetylene gas used with the character employed (one-tenth of a second flash and nine-tenths of a second eclipse) is extremely small, and the replacement of gas cylinders easily effected.

Captain Tymms remarked that from many standpoints the neon light was the best, as had been proved by tests at Croydon. While neon light has admittedly good fog-penetrating qualities, it is doubtful if this is due to any inherent peculiarity of the light itself. If the efficiency of the neon light is simply due to its colour it would appear that much higher efficiencies could be attained by the use of gasfilled lamps, colour screens and revolving lenses.

Mr. A. G. Watson suggested that it was desirable to try the effect of different arrangements of the tubes forming a neon beacon. Other arrangements could be made which would increase the total intensity and would result in the light being emitted from a larger apparent area. The beacon would, however, then become directional, and would give least light to the man who needed it most—the pilot who had gone off his course.

The form of the neon beacon at Croydon was not, as Mr. Watson implies, decided upon for constructional reasons, but to permit the maximum flux of light to be emitted near the horizontal and through 360° in azimuth.

In dense fog it appears immaterial what arrangement of tubes is employed, as the illumination of the fog surface seems dependent rather on the volume than the direction of light. It was noticed during the balloon tests at Croydon that the floodlight, which was sending out a beam horizontally and nearly at ground level, produced a large pool of white light on the surface of a fog 700 feet deep.

Lieut-Col. C. H. Silvester Evans asked for further data on transmission coefficients. The average coefficient of transmission taken when calculating the intensities given by the lenses employed in beacons is 60 per cent. The atmospheric transmission coefficients used to calculate the range curves were, in the first instance, arbitrary, but have been modified to conform with the data obtained during range tests on a number of different beacons.

Very little information is available as regards atmospheric absorption at high altitudes, but even in the stratosphere the transmission coefficient may be expected to vary. Last autumn a very fine display of the aurora borealis was witnessed at Croydon. Since this phenomenon is due to electrically charged dust received from the sun the transmission coefficient of the stratosphere on that particular night at least must have been below the average.

Professor J. T. MacGregor-Morris suggested that the spectrum of the source might account for the long ranges obtained on the neon beacon. This is at present being investigated, but the work is insufficiently advanced for any conclusions to be reached.

The system of using alternating colours, such as red and green, to give a character is open to the objection that the ranges of two differently coloured lights vary in relation to each other under different atmospheric conditions.

It is interesting to note that by changing the current density through a neon tube containing a small proportion of mercury vapour the colour of the light can be made to alternate from red to white. This would offer a simple means of obtaining the effect suggested.

The Chairman (Mr. J. W. T. Walsh) referred to the formula for the angle of divergence of the beam from the outer elements of a dioptric lens. The formula given is a first approximation, based on the dimensions of the source and lens, which can be applied with reasonable accuracy to any of the various forms of lenses used. These range from the small drum lens, as used in boundary lights and consisting of a few elements, to the lenses composed of both dioptric and catadioptric prisms used on route lights.

With reference to the "disc" source, it was perhaps not made clear that the substitution of a disc source for a spherical source could only be made in the case of a fixed lens.

It is not claimed that the equations given are rigidly correct mathematically; it was rather intended to obtain formulæ by the aid of which comparisons could be quickly and easily made.

Some Problems in Illuminating Engineering

(Proceedings at the meeting of the Illuminating Engineering Society, held at the E.L.M.A. Lighting Service Bureau, 15, Savoy Street, London, W.C., at 6-30 p.m. on Tuesday, March 22nd.)

A NEW departure was made at the meeting of the Illuminating Engineering Society on March 22nd, which was devoted to a series of problems in illuminating engineering, introduced by different speakers, who suggested solutions in each case. The chair was taken by Mr. ARTHUR BLOK.

After the minutes of the last meeting had been taken as read, the names of the following applicants for membership were announced:—

Cooke, L. E.	Assistant Engineer and Lighting Superintendent, New South Wales Government Railways, 61, Hunter Street, Sydney.
Turnbull, A. F.	Lighting Superintendent, New South Wales Government Railways, 61, Hunter Street, Sydney.
Crownshaw, H.	Electrical Engineer, Hobury House, Darley Road, Colombo, Ceylon.
Jesson, G. E.	Supervising Electrical Engineer, 18, Cahir Street, London, E.14.
Thompson, H. H.	Managing Director of Holophane Ltd., Elverton Street, Westminster, S.W.1.

The CHAIRMAN then called upon Mr. L. M. TYE, who described, as an example of decorative lighting, the lighting of the Greyhound Theatre and Dance Hall at Croydon.

The next item was the description by Mr. W. MILLNER of an unusual cornice-lighting installation, the lights being arranged round the cornice of the dome of the Cathedral of St. Sophia (St. Petersburgh Square).

Mr. H. H. LONG next described the lighting of a greyhound racing track, explaining how floodlight projectors could be arranged to illuminate the track without causing glare in the eyes of spectators. Mr. L. E. BUCKELL dealt with two interesting problems: the lighting of a corner shop window visible from two sides and the lighting of a shop in which furniture was displayed, the chief feature being the combination of colours to produce a striking display.

Mr. J. S. DOW presented a description by Mr. A. CUNNINGTON of the lighting of a suburban station platform, the aim being to eliminate glare from the platform units, which, in their original form, dazzled the eyes of the engine-driver and rendered it difficult to see distant signals. Mr. Dow then dealt briefly with the problem of improving the efficiency of projectors (optical lanterns and cinematographs), and raised the question whether it was possible by any means to produce an image brighter than the original source.

An interesting discussion followed, in which Mr. W. E. BUSH, Mr. W. C. RAFFÉ, Mr. S. G. ELLIOTT, Mr. G. HERBERT, Mr. R. A. IVES, Mr. H. ALLPRESS, and others took part. Mr. Elliott referred to various problems encountered on the underground railways, and Mr. Herbert described the lighting of the garden at the Ideal Home Exhibition.

After a vote of thanks had been passed to the authors and to Mr. A. Blok for presiding, it was announced that the next meeting would be held on April 26th, when, by the kind invitation of the Directors, a visit to the National Physical Laboratory had been arranged.

(*A fuller account of this discussion will appear in our next issue.*—ED.)

The Standard Specification for Street Lighting

(Proceedings at the meeting of the Illuminating Engineering Society held at the G.E.C. Research Laboratories, Wembley, on Tuesday, March 8th, 1927.)

IN our April issue (p. 106) we gave a general account of the proceedings at the meeting of the Illuminating Engineering Society, held at the G.E.C. Research Laboratories on March 8th, when the Specification for Street Lighting, drafted by the sub-committee of the British Engineering Standards Association Sectional Committee on Illumination, was discussed.

In what follows we give a fuller account of this discussion, which was generally considered to have been a very instructive and useful one.

Mr. C. C. PATERSON (Chairman of the committee) opened the discussion by presenting a summary of the new specification on street lighting drafted by the B.E.S.A. sub-committee. Before proceeding to review the chief clauses he drew attention to the preface to the specification, quoting the last paragraph: "There is no doubt in the minds of those responsible for this specification that during the next few years the trend will be, and should be, towards higher and better distributed street illumination, and the standards have been set to anticipate the immediate future rather than to stereotype the past." Mr. Paterson also recalled the draft clauses for a specification for street lighting formulated by the joint committee composed of representatives of the Illuminating Engineering Society, the Institutions of Gas and Electrical Engineers, and the Institution of Municipal and County Engineers, and presented by Mr. A. P. Trotter in his paper before the Illuminating Engineering Society in 1913.

This marked the initiation of attempts to frame a specification of street lighting, and since that date the requirements had been the subject of much study. At the same time those present should bear in mind that as yet there is no ordered classification of streets, and no authoritative guidance of those responsible for the ordering and supply of street lighting installations; and likewise no generally recognized technical conditions for acceptance or maintenance tests of street lighting installations.

Bearing these facts in mind it seemed that the right course was to lay down a broad classification in terms of illumination, framed in such a way as not to hinder future developments. Everyone agrees that illumination was one, and probably the dominating, factor in street lighting. The committee, whilst abstaining from any attempt to classify streets according to traffic or other similar gradings, had adopted in Table I seven classes of streets graded according to the illumination which they should receive. It was for the local authority to determine in which class any street should be placed. Possibly classification of streets according to traffic and other requirements might be undertaken by traffic authorities; but it was felt to be premature to attempt this at the present stage. The highest class (A) would receive a minimum rated mid-span illumination of 2 foot-candles, and was obviously intended for exceptional thoroughfares. The next four classes, B to E, received illuminations of 1.0, 0.5, 0.2, and 0.1 foot-candles, and there were two final classes, F and G, which might be regarded as the least important and outlying streets, for which 0.05 and 0.02 foot-candles respectively were allotted.

An important consideration in street lighting is the limitation of glare. This is obviously a difficult problem, but the series of minimum heights specified in Table II, ranging from 30 feet for class A to 13 feet in classes F and G, was in itself some safeguard. Everyone agreed that diversity of illumination and glare played a very important part in street lighting. But knowledge of these factors was not yet sufficiently precise to enable them to be incorporated in mandatory clauses. It was stated in clause 14 that installations should be free from objectionable glare. In addition, there was a basis for defining glare, due to Mr. Walsh and explained in his recent paper before the Institution of Electrical Engineers, which the committee considered might be made available in a tentative way for those concerned with street lighting. With the help of Mr. J. M. Waldram this glare proposal had been elaborated and reduced to a practicable form in one of the appendices to the draft specification. Its application was not mandatory, but tenderers for installations under the specification were required to work out and state this glare factor in each case, for the guidance of the purchaser.

The actual mandatory clauses of the specification were simple and few in number. Clause 8 defined the illumination for each B.E.S.A. class of installation, and clause 10 was designed to safeguard the public in the matter of the maintenance and running of installations in a reasonable state of efficiency. In clause 13 it was specified that posts should not be further apart than a distance equal to 12 times their height. This mainly concerned the lowest categories of lighting installations, and particularly those which bordered on what the preface termed "beacon lighting."

The specification also contemplated two values for an installation; firstly, that for which it was designed and to which it must comply when first accepted when everything was clean and new, and, secondly, that below which it must not be allowed to fall by the maintenance authority when reasonable allowance is made for soiled surfaces, variations in lamps and burners, and fluctuations in voltage or pressure. The second condition was permitted, as a minimum, to be one-half the first.

The conditions under which tests should be made of installations, firstly for acceptance when new, and secondly in subsequent service, were laid down in clauses 15 to 20.

Of the three appendices, No. 1 expanded the testing clauses in certain detailed particulars, No. 2 was for the purpose of explaining the expressed "mid-span point" as used in the specification. No. 3 gave figures to assist the correction of candle-power of electric lamps back to normal volts, and No. 4, with its series of curves, gave all the directions necessary for finding the "glare factor" for any installation.

The specification was only regarded as a first step, but it was felt that its adoption and use could not fail to advance the art of street lighting in this country. In conclusion Mr. Paterson expressed, on behalf of his colleagues on the committee, the assistance they had derived from many quarters, not forgetting the labours of the joint committee, whose conclusions were embodied in the paper read by Mr. A. P. Trotter before the Illuminating Engineering Society in 1913.

Mr. J. M. WALDRAM, who followed, said that the problem of glare in street lighting was one of considerable difficulty. It was the more difficult by reason of the fact that, although most persons had a fairly clear idea of what is implied by the term, yet its precise definition was by no means easy. Furthermore, it was also difficult to define some quantity which was capable of measurement and which would be a true measure of glare.

It would perhaps assist in the clearer understanding of the problem if one first considered the general question of visibility in an artificially illuminated street. The degree to which a given object would be more or less noticeable was dependent upon two quite distinct factors which had been called, respectively, the subjective and the objective factors, each of which was related to the illumination conditions in the street. The subjective factor might be described as the perceptive state of the observer's eyes, depending upon the conditions under which they were called upon to perform and by reason of which he was able to perceive any contrasts which might be presented. The second, or objective, factor was the extent to which an object in any given position would be caused to present a contrast by which it may be detected. These two factors in conjunction made up what had been termed the "noticeability" of

the object. An object might be less noticeable (1) because although it presented a reasonable contrast, the sensitivity of the observer's eyes was reduced to a point when they had difficulty in seeing it, or (2) because although the observer could perceive small contrasts, yet the object presented a contrast which was too small. The subjective factor was determined by the two quantities of adaptation and glare, and for any given street installation would vary with the position of the observer, and the objective factor was dependent upon the spacing and height of the fittings, the distribution of illumination along the street (i.e., the diversity) and the reflection characteristics of the object and of the street surface. It would vary with the position of the object, and, to some extent, with the position of the observer.

The question of glare was, therefore, concerned with the subjective factor alone. A figure for glare was not, and could not be, a measure of the visibility conditions in the street. In the specification, the committee had avoided the actual definition of glare and had concerned itself rather with its effects. Evidently, if it was a matter of safeguarding users of the road against dangerously glaring fittings, it was the subjective factor which was of importance, and the method used in the specification was one which aimed at preventing the perceptive condition of the observer's eyes ever being reduced to the point where normal contrasts could not easily be perceived.

The method actually used was due to Mr. J. W. T. Walsh, of the National Physical Laboratory, and was based upon the results of laboratory experiments by Professor U. Bordoni. Bordoni took, as the criterion of the perceptive condition of the observer, the least contrast which could just be detected. The reciprocal of this he termed the coefficient of perceptibility, or, as other workers have named it, the contrast sensitivity. This perceptibility he found to be dependent upon three quantities, viz., (1) the field brightness to which the eye is subjected, (2) the glaring illumination which is received on the eye of the observer, and (3) the angle at which the glaring illumination is received. He found that if the source of light subtended an angle of less than 3° at the eye (a condition which was fulfilled in street lighting) it was the candle-power and not the intrinsic brilliancy *per se* which counted. The curves connecting perceptibility with these three quantities were diagrammatically as shown in Figs. 1, 2 and 3.

By combining these three curves one could work out for each street the candle-power which would suffice to produce a given perceptibility for each angle from the horizontal, the process being indicated diagrammatically in Fig. 4.

For each angle θ one could calculate the intensity which would be necessary just to reduce the observer's perceptibility to a given value, and if these intensities were plotted at their corresponding angles the result would be a curve, as shown. If a lighting unit could be designed to give a polar curve of this form, the perceptibility of the observer would be constant all along the street.

This curve applied to one given height of post only: to make it applicable to all heights, the curves were given in terms of the quantity $\frac{I}{(h-5)^2}$ (the significance of which was clear from Fig. 4), so that the necessary correction was made. Curves prepared in this way were given at the end of the specification for each class of street. Two illustrations of the method of using them would be found on page 24 in the specification. The curves were shown as nearly straight lines on the polar diagram, and had been prepared in terms of a quantity G, which was, as a matter of fact, proportional to the least perceptible contrast and inversely proportional to the perceptibility. The value assigned to the curve which was just tangential to the curve of m for the light unit (where m is the intensity of the unit in any direction divided by the square of its height above the observer's eye) gave the least contrast which an observer could detect in the street when he was at the position where the glare was worst.

In the whole question of glare the committee had legislated always for the worst conditions, in order to be on the safe side. It must be remembered that the data upon which the method was based were obtained under laboratory conditions not primarily intended to apply to street lighting, and, in consequence, certain not unreasonable assumptions had to be made. A difficulty also arose in assigning some value to the coefficient G to be taken as a guide in assessing various cases so that the user might know whether a given value signified a good or a bad installation.

In view of these facts the method put forward in the specification could hardly be regarded as final, but he

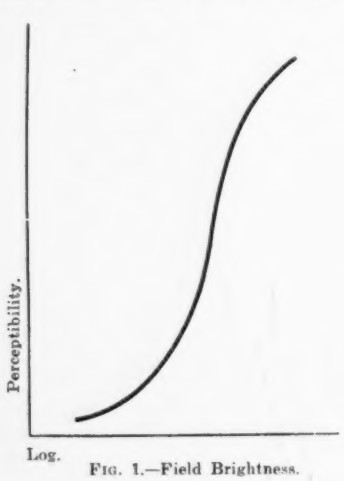


FIG. 1.—Field Brightness.

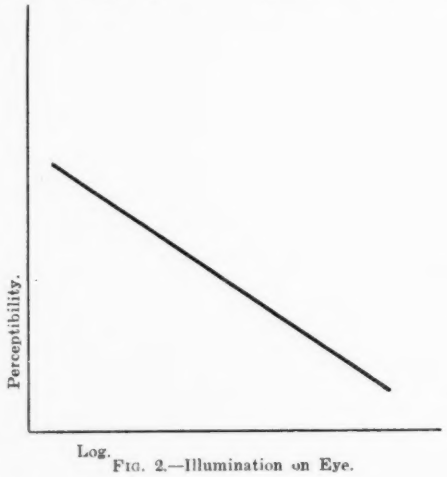


FIG. 2.—Illumination on Eye.

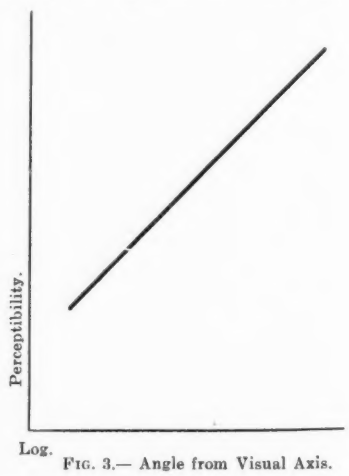


FIG. 3.— Angle from Visual Axis.

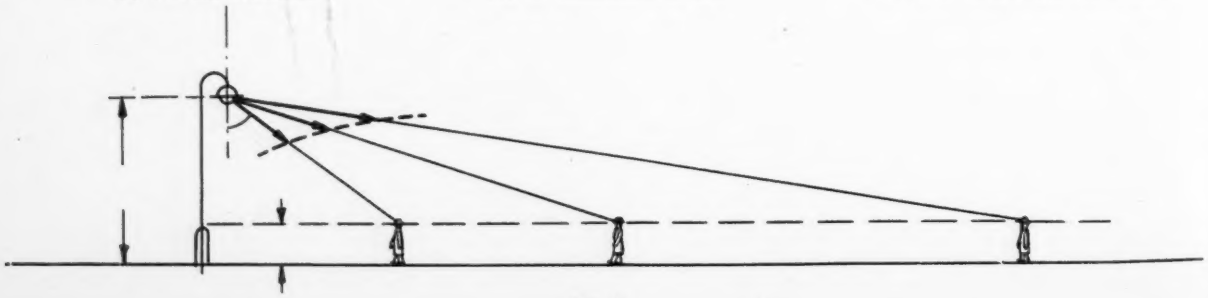


FIG. 4.

thought that any alterations which later experience might dictate would be in detail rather than in principle. It would be a considerable help if Bordoni's experiments could be repeated with the particular object of exploring in greater detail the conditions which apply particularly to street lighting.

Mr. W. J. JONES expressed his great appreciation of the careful guidance of the Chairman of the B.E.S.A. sub-committee during its meetings. It had not been an easy matter to arrive at definite conclusions; and the fact that they had been able to produce a specification was very largely due to his skilful supervision. He hoped that the meeting would provide an opportunity for comments by experts who were not themselves, like himself (Mr. Jones), members of the sub-committee. He felt sure that their suggestions would be very welcome to the sub-committee in indicating any difficulties that had to be met.

He would, however, like to make one little suggestion, namely, that the classification of roads should be taken up as soon as possible. Possibly the time was opportune for some other committee, appropriately constituted, to consider this problem. He believed that its solution would add very materially to the usefulness of the specification.

Mr. A. CUNNINGTON expressed his admiration for the practical nature of the specification. He had been impressed by the fact that it could be put into the hands of any district surveyor, and would be readily understood. The sub-committee had put nothing in the body of the specification that could be said to approach a formula, and the calculations were presented in such a simple manner that the subtleties behind were not evident. The sub-committee were to be congratulated on the simplicity and clearness of the whole thing.

The specification was certainly a vindication of Mr. Trotter. It was very interesting if, as appeared, the idea of minimum horizontal illumination was now completely established. He took it that he was right in assuming, as several gas interests were represented on the committee, that the basis of the specification had the cordial support of the gas industry. At the time of Mr. Trotter's draft specification there was undoubtedly a very strong feeling in some quarters against the specification of minimum illumination. He hoped that the issue of this specification meant that this principle had triumphed.

There were one or two practical points he might mention. He was glad to see that service illumination was put as low as half the rated illumination. This might appear somewhat pessimistic, but those with practical experience would doubtless agree that under normal weather conditions a 50 per cent. service illumination was a very fair figure. He had recently been surprised to find that some public lamps which looked fairly right to the eye were actually furnishing only one-eighth of the figure for candle-power given in the specification.

He was very glad to note that a figure as high as 13 feet had been adopted for fittings in Class G. An extra foot of height in such cases meant an immense improvement, and the additional 2 feet beyond that still prevalent in such installations was well worth insisting upon.

It appeared that there was no reference in the specification to the diversity ratio. Apparently it was assumed that if the minimum was adequate the maximum could be disregarded, but he (Mr. Cunnington) did not feel quite satisfied on this point. From his personal experience of platform lighting—which had a close resemblance to the problem of street lighting—he had been much impressed by the great benefit as regards visibility when the diversity ratio could be kept within reasonable bounds. He had an impression that a very high illumination immediately under lamps had a distinctly adverse effect on the visibility of objects in the less-brightly illuminated portions of a street. He would like to hear the views of other members on this point.

CAPTAIN W. J. LIBERTY expressed his complete agreement with the minimum height of 13 feet recommended in the specification to which Mr. Cunnington had referred. He would not like it to be thought that he personally would dream of adopting a height as low as 11 feet now. Heights of this order were fixed years ago, when much lower illuminations were provided. Now that sources of much higher candle-power were being used correspondingly increased heights were desirable, but it would be appreciated that the change could not be made without a certain amount of expense to the local authority, and naturally this aspect had to be considered.

Captain Liberty also presented a letter from Mr. J. F. COLQUHOUN (Public Lighting Engineer to the Sheffield Corporation), who expressed his regret at his inability to be present, and wished to bring before the sub-committee certain points in the specification which might present difficulties.

Attention was called to the combined effect of clauses 9 and 10 in the specification. The former prescribed that " the illumination at any one mid-span point under rated conditions shall not be greater than three times nor less than one-half the minimum illumination specified." The latter stipulated that the minimum service illumination should not be less than one-half the rated value. Was he correct in assuming that there might be some abnormal mid-span illumination that was, say, only one-fourth of the rated value—for example, that in a street in Class B the actual mid-span illumination might be only 0.25 instead of 1 foot-candle?

The next point referred to the interpretation of the instructions for testing in Appendix I. When the horizontal illumination fell below 0.05 foot-candle it was permissible for the latter to be calculated with the aid of a measurement made with the test surface normal to the light rays. This, he thought, would not be clear to many people, and the point should be elucidated by actual examples.

From the diagrams given in Appendix II (p. 13) it would appear that only the lighting of the carriage-way, but not the footpaths, was considered. Hence the specification might be interpreted to allow the footpath and the curb-line (a very important part of the street) to be left in shadow, although the minimum illumination at the points shown on the diagram of the carriage-way would be comparatively high. The result would naturally be far from pleasing.

Whilst he would not advise the creation of any more classes in Table I, he thought that the difference between Class F (0.05 foot-candle) and Class G (0.02 foot-candle) was very considerable. This point deserved discussion, as side streets and residential streets would always form the great bulk of public lighting.

The minimum height specified could easily be applied, except the lowest class, for which " preferably 13 feet " was specified. It would be difficult to secure compliance with this requirement in practice. In Sheffield the usual height was 11 ft. 6 ins. If this height was raised to 13 feet unwieldy ladders would have to be carried by the men engaged in maintenance and cleaning. The notes on testing electric lamps in Appendix I and the curves and tables in Appendix III were interesting and useful; but he did not see any clause in the specification to protect the local authority, as purchasers, from unsatisfactory lighting arising from variations in the voltage at which current was supplied.

It would be a useful step to have a sample illumination-test record sheet in the specification, with which results obtained in any locality could be compared. In conclusion, Mr. Colquhoun expressed his appreciation of the great labour entailed in drawing up the specification, which he thought would have proved a big step towards better lighting of our towns and cities.

Mr. W. S. STILES (National Physical Laboratory) said that he would like to endorse what had been said by Mr. Waldram in regard to the specification of glare. It was not always easy to apply laboratory experiments in practice. Hence the application of Prof. Bordoni's result was to some extent experimental. He (Mr. Stiles) had been engaged in studying the problem at the National Physical Laboratory, and this work consisted partly of a repetition of Prof. Bordoni's experiments. He was, however, trying to get a little nearer to actual street-

lighting practice, but he was working on a small-scale model, so that the conditions were not precisely similar, and the same objection would apply.

The work done by Mr. Walsh, which was based on Prof. Bordoni's results, was very valuable and interesting, but not to be regarded as final. He believed, however, that the general character of Bordoni's results had been confirmed by investigations made in the United States. Possibly the work on which he (Mr. Stiles) was engaged would add further verification. But, in any event, it would be easy to make any modifications in the specification that further experience might demand.

Mr. J. S. DOW recalled the discussion of Mr. Trotter's classic paper in 1913, of which Mr. Paterson, in his introductory remarks, had made a generous acknowledgment. He thought it might be expedient for some reference to be made to this past work in the preface to the B.E.S.A. specification. Otherwise those interested might be unaware of the fact that so far back as 1913 a definite attempt to frame a specification was made, and might overlook a good deal of useful information acquired at that time.

As Mr. Cunnington had mentioned, there was then keen controversy regarding the adoption of minimum illumination. Possibly the objections then raised to this method had been overcome. If one single criterion of illumination was to be adopted the minimum horizontal (mid-span) illumination was doubtless the best. But he (Mr. Dow) felt that there was something anomalous in rating streets in terms of the minimum illumination only, and ignoring the total amount of light furnished to a street. The method seemed to favour somewhat abnormal types of fittings which concentrated the bulk of their light in a zone slightly below the horizontal. He believed that the recommendations of the German Illuminating Engineering Society on street lighting were based on average illumination, and he understood that it was also incorporated in some American specifications. The sub-committee might perhaps consider the addition of a value for average illumination as a supplementary basis of rating.

He noted that Clause 9 did not allow the mid-span illumination to be *more* than three times the rated value. He could not quite see why objection should be taken to more light being furnished than that prescribed. On the other hand, as Mr. Colquhoun had pointed out, the combined effect of Clauses 9 and 10 might apparently be that the actual illumination at some mid-span point would be only one-quarter of that specified—which was surely a great latitude to allow.

Several speakers had suggested limiting the diversity factor. But, having ensured a minimum illumination, it would surely be illogical to penalize contractors for furnishing more light in other parts of the street.

It had often been remarked that the eye failed to notice quite remarkable variations in illumination, provided the transition was gradual and integrated the impression as a whole. Hence the popular verdict was often based mainly on the total flux of light that the street received. The most important consideration was that there should be no sudden contrasts, and, therefore, the requirement that illumination must be "reasonably graded" was vital. Greater precision in this clause, though difficult, would be desirable. Possibly a requirement that the variation in illumination per foot of street must not exceed a certain value might be considered.

Mr. Dow also referred to the treatment of glare. The problem was a difficult one, and he quite recognized that the method worked out by Mr. Walsh and Mr. Waldram was tentative and experimental. But he could not help thinking that there was something fundamentally wrong with a method that took no account of the screening of a source; and implied that a bare filament and a filament in an opal globe were equally glaring if the candle-power in the specified direction was the same. Common experience in the streets seemed to him entirely opposed to this view. Possibly the fact that the eye was more or less dark-adapted, and the rapidity with which lights come into view to a person driving at a high speed, were influential factors not taken into consideration in Bordoni's researches. In any case, he hoped that the specification would not be interpreted to mean that candle-power and height were the only two material factors, and thus act as a discouragement to the design of diffusing globes and lanterns, on which so much effort had been expended during recent years.

In conclusion, Mr. Dow said that he raised these points in order to illustrate objections that the sub-committee should be prepared to meet. At the same time he fully realized the difficulty of their task. Agreement on a specification was in itself a great step, even if it contained some almost inevitable imperfections and required subsequent amendment.

Dr. S. ENGLISH also complimented the sub-committee on the simplicity of the specification, and especially on the way they had reduced the complex question of glare to a simple expression. There were, however, a few points on which it might be more explicit. In any specification one always looked for perfectly definite statements of what was required, and in this respect he thought that the phrase "reasonably graded" in Section 11 was unduly vague, and the meaning of this phrase should be set out more clearly. The matter was of some importance, as he did not think that the minimum illumination alone was quite satisfactory or sufficient as a basis of street grading.

In a specification one also looked for possible loopholes, and in his opinion one occurred in Section 16, where it was specified that "lamps, lanterns, glassware and burners shall be new and clean," but he thought that there should also be a requirement that the lamps used for test purposes should be *standard commercially available lamps* of precisely the same rating as the circuit voltage. Evidently the illumination could be considerably increased by inserting electric lamps that were run somewhat above their accurately rated voltage, and as the B.E.S.A. specification allowed a small variation in the voltage rating of lamps, it would be easy for a contractor, if he so desired, to obtain lamps whose correct rating was, say, 190 volts, although they would be marked 200, and with such lamps something like 8 per cent. better illumination would be obtained than by using accurately rated 200-volt lamps. Hence the specification should ensure that lamps used were accurately rated, and they should preferably be supplied for the test by the street authority and not by the contractor.

In regard to Appendix I, he pointed out that the data relating to the variation in candle-power of gas burners under varied conditions were not furnished in the same way as they were for electric lamps. If the specification laid down that corrections were to be made, then the data by which this could be done should be furnished. If such data were not available it was useless saying that corrections should be made.

Mr. T. E. RITCHIE expressed his confidence that every member of the society would welcome the issue of a definite specification which would enable schemes of street lighting to be prepared and compared on a uniform basis, and which was so drafted as to prove acceptable to all concerned. Such a specification had been wanted for a very long time.

He believed that if only a single criterion was adopted the idea of specifying mid-span illumination was absolutely right. The location of the plane in which the illumination was to be measured was possibly more debatable, but this point would no doubt receive the careful consideration of the sub-committee after they had reviewed all the comments submitted to them.

As regards the minimum height of 13 feet specified in clause 12, he did not think there would be any difficulty in raising any existing 10 or 11-foot gas-lighting standard up to the level of 13 ft. 6 in. The process was quite simple and also should prove inexpensive. He considered that this minimum height should be maintained in all circumstances.

Mr. C. A. MORTON pointed out that an examination of the two tables would reveal that a high diversity factor would mean the use of abnormal fittings. For example, in the case of a street in Class B, furnished with a minimum mid-span illumination of 1 foot-candle, there would be 10 foot-candles beneath the lamp if the diversity coefficient was 10. The post for this class of

street would have to be 25 feet high. Hence the candle-power in a directly downward direction would be well over 6,000. The fitting would thus be a very abnormal one for that diversity factor.

Mr. A. BLOK agreed with the last speaker that in a specification, which might possibly become the basis for lawsuits, it was hardly sufficient to specify that the horizontal illumination should be "reasonably graded." In spite of the recognized difficulty in stating a diversity factor which would accord with practice, he felt that some numerical indication should be given.

Another point he would like to raise was the definition of the word "height" which occurred frequently in the specification. Was there not here also a possible loop-hole? One assumed that by "height" the height from the ground to the centre of the source of illumination was intended. If so, should not this be stated? When one was dealing with translucent lanterns, one was in fact dealing with sources of considerable dimensions, so that the precise definition was of some consequence.

He also noticed that on page 8, in the paragraph dealing with test conditions, it was specified that lamps, lanterns, glassware and burners must be new. Might not that provision occasion some difficulty? When the specification came into operation, and one sought to apply it to existing installations the lamps and lanterns in use would naturally not be new. He assumed that the paragraph meant that the lamps, glassware, etc., should be in good condition—not necessarily brand new from the factory. This seemed to be a point worth reconsideration.

In conclusion, Mr. Blok expressed his admiration for the work of the sub-committee. Everyone must appreciate the difficulty of their task, and the sub-committee deserved the gratitude of the public and the lighting industry for the excellent work they had done.

Mr. L. B. W. JOLLEY said that he had observed in the current issue of *The Electrical Journal* (U.S.A.) an excellent article on the appraisal of street lighting. He thought that this contribution deserved study, although one might not agree with the author's adoption of average illumination as the criterion of street lighting.

He noticed that the specification made frequent use of the word "glare." There were many forms of glare, and the phrase was somewhat too general. He stated that the term "coefficient of ocular insensitivity" had been suggested, and it described exactly what was meant, although the phrase was somewhat clumsy. There was one point in connection with Bordoni's researches that deserved to be emphasized. His conclusions applied only to sources subtending a relatively small angle at the eye, not greater than 3°. It might be urged that in the streets one was not concerned only with very distant sources, and that at fairly close quarters this angle might be exceeded.

He hoped that the various queries that had been raised would receive consideration from Mr. Paterson and Mr. Waldram in their final reply to the discussion.

Mr. HAYDN T. HARRISON (communicated): As a member of the Joint Committee of 1911-12, which met under the chairmanship of Mr. A. P. Trotter, and also of the B.E.S.A. sub-committee, whose draft specification is now being discussed, I fully realize the difficulty of the task. I can, in fact, endorse a remark attributed to Mr. Preston Millar, who, in discussing the work of the street-lighting committee of the American Illuminating Engineering Society, stated (if my recollection is correct) that they had had "a hell of a job"! I wish to congratulate Mr. Paterson on having brought this work to such a satisfactory conclusion, as the draft specification before us reveals.

The specification is a thoroughly practical piece of work. I feel convinced that if municipal and other authorities who have to deal with street and road lighting will only make use of it, the streets of this country will soon present a very different appearance by night, and will be very much less dangerous places than they are at the present time.

In comparing the schedule of minimum mid-span illuminations with that presented in Mr. Trotter's paper, it will be observed that the minimum for the lowest class is now 0.02 instead of 0.01. But in the case of the 1913 specification the illumination was to be measured 3.25 feet above the road level, and in the case of lamps spaced at considerable distances (150 or 200 feet) this makes a considerable difference and brings the values more into line than might appear at first sight.

Nevertheless a much higher degree of illumination than is generally found in practice is now demanded. Take, for example, a street with light sources placed 150 feet apart and 12 feet high. It is then necessary to provide light sources giving over 350 candle-power in order to obtain the 0.02 foot-candles demanded by the present specification. Yet all over the country it is the common practice to provide only 70 to 100 candle-power. If the height of the light source were raised to, say, 17 feet, 275 candle-power would be sufficient for the same spacing. This shows that the increased heights recommended in Table II have advantages besides the diminution of glare.

I have only two faults to find with the specification. Firstly, the opening note suggests that relatively low candle-power units placed at great distances apart are a form of street lighting; I would prefer that this form of lighting should in future be known as "beacon lighting"—the term mentioned in the preface.

Secondly, the very valuable appendix on glare does not make it obvious that the coefficient G is a factor which applies only to actual users of the street or road; and not to those who, when asked to consider the question of glare, immediately look at the light source. The term I (luminous intensity) does not take into consideration intrinsic brilliancy, which is, of course, unnecessary where the light source does not come into the field of vision. Therefore, the formula has its limitations, which must be obvious when many forms of glare, such as the glare of the desert, snow blindness, etc., are recalled.

In conclusion, I should like again to express the hope that the specification will be generally adopted, with such revisions as will no doubt become necessary from time to time.

The CHAIRMAN (Lt.-Col. K. Edgcumbe) remarked that the discussion had been an interesting one. He was glad to find a general recognition of the value of the work done by the sub-committee and of the difficulty of their task. He would like to add his word of thanks to Mr. Paterson for serving as chairman of the sub-committee, and for his excellent work in connection with the specification. Mr. Paterson's task had been a most difficult one, and he had never thought, when Mr. Paterson commenced his work, that the specification would appear in draft form at such an early date.

Mr. L. GASTER recalled the paper read by Mr. Trotter in 1913, when the terms of the specification drafted by the joint committee representing the Illuminating Engineering Society, the Institutions of Gas and Electrical Engineers, and the Institution of Municipal and County Engineers was presented. On that occasion it was the unanimous feeling of the bodies represented on the joint committee that the platform of the Illuminating Engineering Society was the only one on which the specification could be adequately and impartially discussed. He was, therefore, glad that the opportunity had been taken to bring the B.E.S.A. specification before the society. He felt sure that all present recognized the difficulty of the task of the committee, and he hoped that the discussion would prove useful to them.

Mr. Gaster also proposed a very cordial vote of thanks to the Chairman (Lt.-Col. K. Edgcumbe), to Mr. Paterson and Mr. Waldram for opening the discussion, and to the General Electric Co. Ltd. for their hospitality in allowing the society to hold their meeting at Wembley, and at the same time providing an opportunity for members to inspect the laboratories. He felt sure that they had all found the visit extremely enjoyable and instructive, and could not help being impressed by the sagacity and foresight which the Company had shown in establishing these research laboratories. He felt sure that their action in this respect had been fully justified by the admirable work done by Mr. Paterson and his staff. The motion was seconded by Capt. LIBERTY and carried with acclamation, and after Mr. Paterson had briefly replied the meeting terminated.

Mr. C. C. PATERSON, in reply: I have listened to this discussion with the greatest interest and satisfaction, and desire to express our thanks to everyone who has contributed to it. The comments and criticisms on the draft specification have all been constructive and helpful, and I would assure those who have been good enough to make them that all the suggestions will be carefully considered by the committee whose task now is to review their tentative proposals in the light of criticisms received so that the final specification may receive as wide support as possible.

There is not space to reply here in detail to every speaker, and I must perforce limit my reply to those points in the discussion which have attracted most comment.

One sound criticism made by several speakers is that, whilst prescribing the minimum illumination and giving guidance as to avoidance of glare, the committee has not taken account of the diversity of illumination. (The expression " reasonably graded," in clause 11, was only intended to prevent sudden shadows and streaks of light on the road.) Another way of stating the same matter is that as the specification stands two installations will be classed the same because they have the same minimum illumination, but their average illuminations may differ widely, and, on this account, one may be much better than the other. Experts do not yet agree which is the better from the point of view of visibility—the uniformly illuminated street or that with considerable diversity of illumination—and the committee was in the same position. They therefore felt that until opinion was more definitely established on the question of " diversity " it would be premature to seek to prescribe for it in a specification. The question of " glare " is not quite in the same category because, whereas it is true that its precise definition is still being argued, it is universally admitted to be inimical to good visibility, and, furthermore, we know quite well what are the main factors which cause it. We have been so impressed, however, with the need of more information on the question of diversity and its influence on visibility in streets that we have enlisted the interest of the Illumination Committee of the Department of Scientific and Industrial Research, and we hope that the result of their work will be to show how this phase of the question should be dealt with in any future revision of the specification.

Mr. Colquhoun's suggestions are important, particularly that to add another class of street between F and G. The committee appreciated that the footway was as important as the carriage-way, and therefore prescribed that readings must be made on the curb line. They could not well go to the side of the footway remote from the curb because illumination readings there are liable to be unrepresentative owing to the proximity of reflecting surfaces, the nature of which is quite fortuitous. Mr. Colquhoun would like to see in the specification protection for the local authority who purchases electricity for street lighting against voltage variations. It seems to me that it is hardly the function of a specification to give any such protection. It should rather be framed to strengthen the hands of the purchaser of electricity against a supply undertaking which fails to fulfil its statutory obligations as regards voltage fluctuations.

I find Mr. Dow's comments very valuable. He also calls attention to average illumination as a factor which should not be ignored. On clause 9 it is to be remembered that " mid-span " illumination is the average of the illuminations at five consecutive mid-span points, and it is necessary to ensure that there is not unreasonable lack of uniformity amongst the five spans. On the question of glare it has, I think, been established by all experimenters that, provided the source of light subtends an angle which is anyway less than the resolving power of the eye, the luminous intensity, and not the intrinsic brilliancy, is what matters, and, as has already been pointed out, experiment appears to indicate that luminous intensity continues to be the dominating factor until the source subtends an angle exceeding 3° at the eye.

Several speakers commented on the making of 13 feet the minimum height for light sources, and, on the whole, I think the preponderance of opinion at this meeting supports the committee's proposal. One has seen the ease with which existing posts have been fitted with light and not ungraceful extensions which cannot have added much to their cost.

The expression " ocular insensitivity," which Mr. Jolley attributes to Mr. Walsh, is correctly descriptive of what we mean when we talk of glare in connection with street lighting.

In conclusion, may I again thank you on behalf of my colleagues on the B.E.S.A. Street Lighting Specification Sub-Committee for the reception which you have given to their efforts.

Mr. J. M. WALDRAM, in reply: Various speakers have raised points in connection with the glare clause which are of considerable interest. It is particularly interesting to note Mr. Stiles' remarks, and to know that the results of Professor Bordoni are to be confirmed in this country. The original work certainly requires extension in the particular region applying to street lighting.

Mr. Dow refers to the effect of diffusing glassware and other devices for reducing glare, and notes that the specification takes no account of such devices.

According to Bordoni's results, and also according to the findings of the Committee on Glare of the Illuminating Engineering Society of America, diffusing glassware, " while it may lessen discomfort, does not affect the depression of sensitivity of the observer except in so far as it lowers total candle-power." (Trans. I.E.S., June, 1916, Vol. XI, p. 423.) The opal globes commonly used in street lighting do, however, reduce the candle-power of the source considerably, which may possibly account for the impression which Mr. Dow has received from practical experience. Of course, if the glassware were very large indeed so as to subtend a large angle at the eye a smaller reduction in perceptibility might be realized by its use.

Mr. Paterson has already dealt with the matter of diversity, to which several speakers have referred, but there are two points in connection with that quantity which may be mentioned. In the first place, in any given installation, if the spacing ratio, minimum illumination and possible polar distribution are fixed the diversity is automatically fixed, as Mr. Morton has pointed out; and, if a limit were placed upon diversity in either direction, the designer would probably be very severely hampered.

Secondly, there is the vexed question as to the desirability of diversity. While we do not yet know enough about the subject to make definite statements yet I would suggest that the protagonists of even illumination, i.e., low diversity, have to reply to the following point:

If there are two streets in which the minimum illumination and spacing are the same, but in which the diversity is different, the one with a higher diversity will have a much higher average illumination. If a low diversity is preferable then it has to be shown why the extra illumination on the road provided by the installation with the greater diversity is detrimental to visibility on the road, as those who advocate even illumination apparently infer.

Visit to the National Physical Laboratory

On Tuesday, April 26th, by kind invitation of the Director, members of the Illuminating Engineering Society and friends paid a visit to the National Physical Laboratory, Teddington. On arrival about 5-30 the party assembled to hear a paper by Mr. H. Buckley entitled " Work in the Photometry Department of the National Physical Laboratory," after which a tour of the photometric section was made, much interest being shown in the apparatus for tests of light and illumination.

A full account of the proceedings will appear in *The Illuminating Engineer* in due course.

Illuminating Engineering Society

(Founded in London, 1909).

OFFICIAL NOTICE

In accordance with the Constitution the following List of Officers and Members of the Council, and of Nominations put forward by the Council of Members who have consented to fill vacancies, is presented for the information of members:—

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THOS. A. EDISON (U.S.A.)
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(3) *Makers of Illuminating Apparatus, Lamps, Fittings, etc. :—*

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Dr. A. H. LEVY (Ophthalmic Surgeon) (1910)

(7) *Interested in General Physics, Science and Photometry :— (Extended)*

Mr. A. BLOK (1912)
Mr. J. S. DOW (1909)

(8) *Interested in the supervision of the Illumination of Buildings, Factories, Schools, etc. :—*

Capt. W. J. LIBERTY (1911)
Mr. D. R. WILSON (1910)
Mr. L. GASTER, F.J.I. (Consulting Engineer) (1909)

Ex-Officio :—

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Hon. Secretary :—Mr. L. GASTER (1909)
Hon. Treasurer :—Mr. J. WYATT IFE (1909)

Members Retired	*Section Represented*
Mr. S. H. CALLOW	(2)
Dr. J. KERR	(6)
Lt.-Col. CORTEZ LEIGH	(4)
Mr. A. STOKES	(1)
Mr. P. SUGG	(1)
Mr. P. J. WALDRAM	(5)

Additions nominated by the Council

President :—MR. D. R. WILSON

(Member of the Home Office Departmental Committee on Lighting in Factories and Workshops; Member of the Illumination Branch Committee of the Department of Scientific and Industrial Research; Secretary of the Industrial Fatigue Research Board.)

Vice-Presidents :—

Mr. C. C. PATERSON
Lt.-Col. K. EDGCUMBE
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Mr. C. C. PATERSON (G.E.C. Research Laboratories, Wembley) (1909)
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(The number in brackets after the names of members of Council indicates the date of election as a member of the Society.)

POPULAR & TRADE SECTION

COMPRISING

Installation Topics—Hygiene and Safety—Data for Contractors—Hints to Consumers

(The matter in this section does not form part of the official Transactions of the Illuminating Engineering Society; and is based on outside contributions.)

The Economics of Light Production

EFFECTS of Voltage Variation.—It is well known that the voltage at the consumer's premises is sometimes different from that at the supply station, and that, moreover, it is also liable to a certain amount of fluctuation; it is useful, therefore, to know how the candle-power of a lamp varies with the voltage. Let us assume that the normal voltage of the lamp is 100 volts, and that the luminous output is 100 units; now if the voltage due to drop in mains or some other cause be reduced to 90 volts, the luminous output is reduced to 67 units. In other words, a reduction of 10 per cent. in the voltage causes 33 per cent. decrease in the candle-power of the lamp. The light emitted by a lamp depends upon the temperature of its operation, and a change of temperature of the filament of 1 per cent. produces a change of light output of 11 per cent. When, as very often happens, a 110-volt lamp is operated on 100 volts with the idea of extending its life, it is obvious that the filament of the lamp will be working below its normal temperature, and the resultant light output very greatly reduced.

Cost of Light.—The cost of obtaining electric light depends upon three factors:—

1. The efficiency of the lamp,
2. The price of the lamp,
3. The price of electricity,

and it will be apparent that the more efficient the lamp the more one can afford to pay for either the lamp or the electricity, in order to get a definite amount of light at a certain cost.

Let us consider a definite case of a 100-watt gasfilled lamp of 1,000 hours rated life and 1,100 initial lumens output, with electricity at 6d. per unit and the cost of lamps at 5s. each. The effect of varying one of the above factors (the others remaining fixed) gives us the following table of lumen hours that can be obtained for one penny:—

	Lumen hours for one penny
All factors normal	1,652
12 per cent. reduction in the price of lamps	1,670
7 per cent. improvement in lamp efficiency	1,673
1.2 per cent. decrease in the price of electricity	1,670

This shows that, in order to produce effects of the same order of magnitude, the change in lamp price must be several times greater than the change in either lamp efficiency or the cost of electricity. In other words, the price of energy and the efficiency of the lamp are the predominating factors in the cost of light.

In the case of the tungsten lamp the cost of electricity consumed during its life is approximately nine times the original cost of the lamp, while in the case of the carbon lamp with the same normal life it is twenty-seven times the original cost of the lamp. In other words, the cost of renewal is of much smaller importance than the cost of electrical energy consumed. Hence, it follows that in order to get the best and most economic results from lamps, *i.e.*, light at the cheapest cost, it may be advisable in some cases to operate the lamp at a higher voltage than that at which it is rated, in spite of the fact that this will shorten its life. Thus the cheaper the lamp and the cheaper electrical energy, the more frequently would it pay to replace lamps. *The policy adopted by some people of under-running in order to extend the life of their lamps will not necessarily give the cheapest results.*

On the contrary, it can be shown that if the price be reduced 8 per cent. it will pay to over-run the lamp by 1 per cent.; and with a 16 per cent. reduction in price it will pay to over-run the lamp by 2 per cent. if the lamp is to be operated with the same economy.

Relation between Voltage, Consumption, Light Output.—When the voltage across a lamp is raised, its consumption in current increases, and therefore the watts on which cost of energy is based. The following table is rather interesting as it indicates the relationship between the voltage of a lamp, the revenue of the central station and the amount of light obtained. It is compiled from the data provided in Figs. 2 and 3. An increase of 1 per cent. on voltage increases the consumption of the lamp by 1.7 per cent., and the output of the luminous energy by the lamp is increased by 4 per cent.

Increase of Voltage Per cent.	Increase of Central Station Revenue Per cent.	Increase of Light Per cent.
1	1.7	4
10	17.0	40

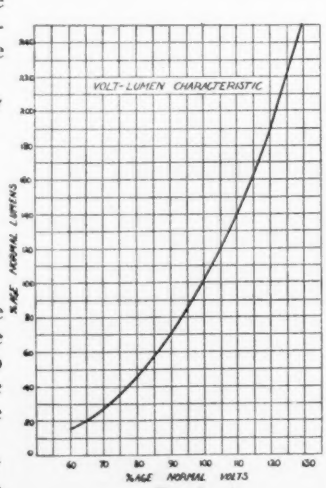

FIG. 1.

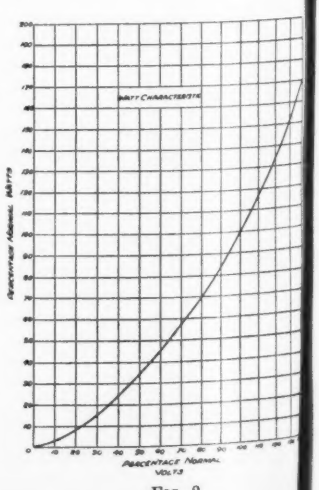

FIG. 2.

Illuminated Aids to Navigation on the

London—Continental Air Route

Of the 52 Lighthouses and Beacons in regular service between Croydon and the coast 51 are of the—

A.G.A. Automatic Unattended Type

Designed and Manufactured to the order of the Air Ministry by

The Gas Accumulator Company (U.K.) Ltd.

Lighthouse Engineers

BEACON WORKS - BRENTFORD - ENGLAND

Each light is equipped to function for a period of six months without human attention.

The design of the equipment is identical with that which, for the past fifteen years, has constituted the Company's Automatic Lighthouse System, in use by the Trinity House and other Marine Authorities throughout the world.

Sheffield Illumination Society

A most interesting and enjoyable afternoon was spent by about 60 members of the Sheffield Illumination Society on the 30th March last, when a visit was made to the offices of *The Sheffield Telegraph*.

The party was received by Mr. A. R. Ridley, on behalf of the Directors of *The Sheffield Telegraph*, who escorted the members through the various departments. To view the latest types of machinery used in the producing of newspapers, etc., was a wonderful sight, and Mr. Ridley explained very fully the different processes that took place.

Before leaving the offices the members were entertained to tea and refreshments, which was much appreciated.

In the absence of the President (Mr. H. Lazenby) through illness, the Vice-President (Mr. J. R. Hall) moved a vote of thanks to the management of *The Sheffield Telegraph* for the splendid facilities that had been afforded to the members of the society and for the trouble Mr. Ridley had gone to in making the visit so very interesting, instructive and educative.

The Lighting of Warships

The recent paper read before the Institution of Electrical Engineers by Mr. W. McClelland contained some notes on lighting in warships. It is pointed out that officers and men spend a considerable time in artificial light, and the importance of adequate illumination is correspondingly great. Methods are limited by restrictions of space and small headroom, and fittings must be rigidly mounted and very robust. Fittings illustrated are either of the bulkhead type or suitable for mounting direct on ceilings, etc. Tables of illumination values, as specified for the British and U.S. navies, are presented. In the former we find a judicious distinction drawn between *minimum* and *average* values. For most purposes the latter is 1.5 foot-candles, whilst the average illumination prescribed is either 2–4, 3–5 or 4–6 foot-candles. The importance attached to glare can be gathered from the recommendation that, so far as possible, fittings should be so designed as to prevent the filament being visible at an elevation of less than 40° to the horizontal, whilst the brightness of luminous surfaces of fittings within the direct range of vision must not exceed 2.5 candle-power per square inch. Special problems are presented in the illumination of chart-houses, etc., and by the decorative lighting, usually in the form of outlining the ship with lamps, on ceremonial occasions.

Scenery Out of Sound

One interesting result of the development of broadcasting has been the realization of the value of sound, as well as light, in conveying impressions. Television may ultimately solve the problem of broadcasting visual impressions of scenery, etc. But meantime we have to rely on sound to develop the atmosphere and enable the audience to form a conception of the surrounding conditions in which the action takes place. Hence the production of suitable sounds to supplement the spoken word has become quite an art. Sometimes the sounds are produced artificially by suitable "props." For example, a realistic forest fire has been created by the use of a plumber's blow-torch for the sound of flame and wind, and by breaking up matches to simulate the sound of crackling, breaking and burning branches of trees. Since the listener is unable to see the actor enter, the character's presence is generally denoted by the closing of a door or by the lines. Hence doors in radio studios are often deliberately made squeaky affairs.

The stage "prop" is rarely suitable for radio use, though the wind and thunder machine of the stage are often used for thunderstorm effects. In the kinema theatre the spectator sees, say, a locomotive, and the supplementary sounds produced in the orchestra pit need not be very accurate to emphasize the effect. On the stage, also, "prop"-produced noises are often poor imitations of the real thing. But the listener to a broadcast programme sees nothing, and the radio microphone is so sensitive that kinema theatre and stage "props" are often useless. A passing train must sound like *a train*, and not like a motor-cycle or a tug-boat. In some cases it is possible to reproduce the actual sounds from nature. Thus, a microphone installed at a busy street corner has conveyed the noise of a crowd. But in many cases imitations are necessary.

Mr. T. R. Clay, Director of the WGY Players of the General Electric Co. of America, has made a special study of these problems and evolved many ingenious devices. One of the most stubborn sound problems encountered was the production of the noises of an express train. Real locomotive bells and a creditable whistle were readily obtained. Boards covered with sandpaper, when rubbed one against the other, produced the "chug-chug" of the engine. A flour sieve helped to convey the first sharp sound heard when the engine puffs. Rolling skates moving over a metal panel imitated the noise of a train bumping over uneven rails. Another effect, also artificially imitated, was the rattling of the window glass of carriages. By such means all the audible impressions of a country station were built up. The whole train effect required the services of six people, one to whistle, one to "chug," one to operate the roller skates, one to make the windows rattle, another to sound the bell, and a sixth to act as control-room operator and control the sound volume.

THE
ELECTRIC STREET LIGHTING APPARATUS CO.

"ESLA"

Illumination Specialists

THE FOUNDRY CANTERBURY

The British Thomson-Houston Co., Ltd., Crown House, Aldwych, London, W.C.2

The Development of Gas Supply in Liverpool

A Fascinating History

Mr. R. E. Gibson, Engineer of the Liverpool Gas Company, is to be congratulated on his interesting lecture recently delivered before the Society of Lovers of Old Liverpool, part of which is reprinted below. The second half of the lecture will appear in a subsequent issue of this journal.

EARLY History of Coal Gas.—The history of coal gas may be said to have covered a period, to date, of 135 years. Although coal gas was discovered as far back as 1688 by the Rev. John Clayton, D.D., Dean of Kildare (and one time Rector of Crofton, near Wakefield), it was not until William Murdoch used coal gas for lighting his house in Redruth, Cornwall, in the year 1792, that it became of any practical importance. It is interesting to note that Murdoch is also credited with having made the first locomotive (also at Redruth) eight years previously.

Murdoch was associated with James Watt in the development of the steam engine; and, following upon his success in lighting his house at Redruth, arranged for the lighting of the Soho Engineering Works of Boulton & Watt, Birmingham. In celebration of the Peace of Amiens, in 1802, the whole premises of this firm were illuminated by coal gas. From that time onward the use of coal gas as an illuminant rapidly came into favour; but not without a certain amount of opposition, prejudice and hostility against the innovation.

Conditions in Liverpool Prior to Introduction of Gas.—The introduction of gas as an illuminant in Liverpool took place in 1816. Prior to that time oil lamps and candles were practically the only means of illumination. The earliest reference extant to the public lighting of Liverpool is mentioned in Picton's "Memorials of Liverpool." In the town records of 1654 it was ordered: "That two lanthorns, with two candles burning, every night in the dark moon, be set out at the High Cross and at the White Cross and places prepared to set them in every night till past eight of the clock, by the sergeant and water bailiffs."

In the issue of *The Liverpool Echo* for February 13th, 1913, some interesting historical notes appeared under the title, "New notes on old acres," by "Pardy." From those notes it appears that, prior to 1817, Liverpool was wretchedly lighted by oil lamps which used to go out on all trifling occasions, and for insufficient reasons. They were only a pretence at the best of times, and not lit in summer or on moonlight nights. The gentry took linkboys with them on their night excursions. The links were made of stiff, tarred rope, about as thick as a man's arm. They gave out a flaring light, and a large quantity of disagreeable smoke. Extinguishers (one of which was kept for many years as a curiosity outside a house in Mount Pleasant) used to be attached to the lamp irons. The extinguishers were quite as clumsy as the links themselves. The appliance was a kind of funnel, about six inches in diameter at the widest end, and was used by thrusting the link up when the light was to be put out. It was quite common in those days for people to trip over into the docks and wharves, and the coroner was fairly busy in this department. Rum (much of it smuggled) was freely drunk, and cases of drowning were frequent and would pass without remark.

In Castle Street each shopkeeper was forced by Act of Parliament to have an oil lamp placed over his door; but this arbitrary proceeding was repealed soon after the discovery of coal gas.

Introduction of Gas into Liverpool.—The new illuminant was introduced into Liverpool in 1816 by a gentleman named Hargraves, who represented himself as having been engineer to a chartered London company, He arrived in Liverpool about August, 1815, waited upon several influential inhabitants, including Mr. John Foster (at that time the Corporation Architect), and attempted to form a company to light the town by coal gas; but his views met with little encouragement. At that time, however, Mr. Jonathan Varty (coach-builder), whose premises then occupied the site of the present offices of the Manchester and County Bank Limited (Dale Street), heard of Hargraves' mission, and, having had an interview with him, they together decided to float a public company, Mr. Varty soliciting his friends to become subscribers to the scheme. The capital of the company was to consist of 500 shares of £30 each. Books for receiving the names of subscribers were placed in the Athenæum Newsroom and in several shops. With some difficulty Mr. Varty succeeded in obtaining a few subscribers, who exacted from him a promise that he would, in twelve months, return them their deposit of £3 per share if the scheme proved unsuccessful. The total amount of money raised by the enthusiastic Mr. Varty only amounted to £70 or £80, with which a small gas apparatus was erected on his premises in Dale Street. After some little trouble, permission was granted by the Corporation to lay down a main and pipes from this small apparatus to the front of the Town Hall, where two large lamps (each containing three lights) were erected. Lights were also exhibited in the shop of a confectioner in Castle Street, and of a hatter in Dale Street.

When the lamps were first erected such wise and business-like men as the directors of the Sun Insurance Company were so terrified at the thought of a general conflagration that they sent Mr. Varty notice that his policy of insurance would be vitiated the moment he lighted the lamps. Mr. Varty, however, persevered, and, at last, the lamps opposite the Town Hall were first lighted—on the 23rd January, 1816. They were surrounded by a crowd of people, many of whom were, like the insurance people, apprehensive of fire; they held their hands against the iron lamp-posts and positively declared that they felt them becoming gradually warm. The experiment having proved successful, gas continued to illuminate that central spot till February 11th, 1816, when the cheerful flame was (probably from lack of funds) discontinued.

The following extract from *The Liverpool Daily Mercury* of January 26th, 1816, is interesting: "Two large gas lamps, with three burners in each, have been lighted with gas and exhibited for the last few nights at the front of the Town Hall. The light is so brilliant that a person may with ease discover the hour by his watch at a distance of 20 or 30 yards. We understand that it is intended to light the dock lamps by this method, and we trust that it will soon become general."

First Liverpool Gas Act.—All this was done before any Act of Parliament was procured, but, ultimately, steps were again taken to form a company, and an agreement was entered into by Mr. J. Varty with Mr. J. Wood, of Cheapside and Hatton Garden, for the lease of a certain portion of his tanyard, where the necessary works were constructed, and trustees were appointed by the company who continued to act till the year 1818, when a Charter of Incorporation was obtained with permission to raise a capital of £50,000 in 500 shares of £100 each.

The first announcement of the Liverpool Gas Light Company appeared in *The Mercury* of June 6th, 1817, and set forth the rates of charges, which were not based (as they are now) on the amount of gas consumed, but on the size of the burner employed.

The cheapest was an Argand No. 2 burner which, for use from sunset to 8 o'clock at night, cost two guineas per annum. No extra charge was made if the light remained burning for a quarter of an hour after the time contracted for, and on Saturday evenings the company allowed burning until midnight. One wonders if they trusted to everybody's honesty, or whether handy scouts were dispatched to see if the lights had been duly put out.

Charging for Gas.—It was soon found that the method of charging for gas by the hour was very unsatisfactory, and, in 1819, the gas meter was introduced, the price then charged being 15s. per 1,000 cubic feet. This much-abused instrument was invented by Mr. Samuel Clegg in 1815, and it stands to his credit that the main principle of the wet meter to-day is still much the same as that adopted by him.

The premises of John Wyke (watchmaker), nearly at the corner of Dale Street and Hatton Garden, were taken over by the old gas company in 1820; the offices were built fronting Dale Street, the works being behind.

When gas was introduced into Liverpool it was chiefly used for shops, the street lamps not being lighted with gas until 1819, when, on September 11th, 30 public lamps in the principal streets were thus illuminated. By the end of the year they had increased to 229.

It is easy to understand how unpopular gas was with the pressgang and the thieves and vagabonds who infested the port in those days, but one would have thought that all would have been heartily sick of the oil lamps and impertinent linkboys, and would have welcomed the new improvement.

This, however, was far from being the case. The inhabitants bitterly complained of the company digging up the streets to put down the pipes. They called gas a "faddists' fluid," the craze of cranks bent upon inconveniencing peaceable folk.

The Oil Gas Company.—The success of the first company led to the formation of a rival undertaking, and in 1822 a company called the Liverpool Oil Gas Light Co. was enrolled to supply the town with gas manufactured from oil, and works were established at Rose Hill. The cost of this gas (45s. per 1,000 cubic feet in the earlier years, reduced to 30s. in 1829) heavily handicapped the undertaking; for we find that in 1824 the other company only charged 12s. 6d. per 1,000 cubic feet and incurred no bad debts, for payment was demanded in advance. There is an indication, however, that the original company must have experienced trouble due to stopped pipes, for Mr. Henry Steel (manager of the rival Oil Gas Company) informed his customers that the gas made by his company did *not* corrode or stop up pipes used to convey it. The Oil Gas Company found that their comparatively high price militated against the development of their business, and in 1834 they went to Parliament, and obtained permission to manufacture gas from coal and any other materials whatsoever. (By their original Act they were precluded from ever using coal.) The new company, after giving up the use of oil, made gas from cannel.

The Liverpool New Gas and Coke Company.—This new policy brought about an immediate and substantial reduction in the price of their gas to 10s. per 1,000 cubic feet, and placed the Oil Company—from that time known as the Liverpool New Gas and Coke Company—in a better position to compete with its rival. Meter rents were, at the same time, instituted. The Chairman of this company was Mr. Harmood-Banner, grandfather of Sir John S. Harmood-Banner, who died quite recently.

The older company soon found it necessary also to adopt the use of cannel, so that their gas might be as high in illuminating power as that produced by their rivals. In 1840 the premier company reduced their price to from 7s. to 8s., according to quantity; and so the competition continued.

The Proposed Guardian Company.—The success of the two Liverpool companies led to attempts being made in 1843 and 1844 to form a third company called the Liverpool Guardian Gas Company. The following extract from the prospectus, dated 13th January, 1844, is of interest:—

"It is true that this town is already supplied with gas to some extent, and works have for many years been established for the purpose; but the population and trade have since greatly increased, and there is a wide field yet open for a company which could at all times give a regular and steady supply of gas at reduced prices. This is evident from the fact of the existing companies making repeated applications to Parliament for enlarging their capital and extending their limits, the increasing demand for the supply of gas, the general feeling that pervades the public in favour of it, as a preferable light to any other (a feeling which will still take a far wider and more extensive range if the cost of the article be reduced); and that light is conducive to health and comfort, which, with improved means for its introduction, will doubtless ultimately cheer the cottage of the poor as well as the mansion of the rich. With respect to the tradesman and the manufacturer, it will be at once conceded to be an indispensable as well as a valuable article, to enable them to conduct their business with advantage."

It is fortunate that the attempt to form this company proved unsuccessful.

Amalgamation, 1848.—The competition between the two then existing companies was the reverse of beneficial to the public or to the rival companies themselves, and ultimately in 1848, by the advice of the Corporation, they were amalgamated. The joint company was named the Liverpool United Gas Light Company. It had three large working establishments, and employed about 400 persons, independently of clerks, collectors, etc. The premises in Dale Street, so long occupied by the company and once so well known for their "Liver" bird and the motto "*Ex fumo dare Lucem*,"* were offered to the Corporation as a suitable site for new police premises. The site is now occupied by the police courts and fire station.

Newington Offices.—When the company found that their Dale Street offices were insufficient for their rapidly growing needs, they acquired land in Newington, and offered a premium for the best design for new offices and workshops thereon. Many architects sent in a variety of designs, none of which, however, gave satisfaction. The company, finding that the architects could not satisfy them, and at the same time being anxious to make use of local talent, said: "Well, if the architects of Liverpool can't give us what we want, let's try the builders!" Due notices were accordingly sent to various local builders, and finally the designs sent in by Messrs. Haigh & Co., Fraser Street, were selected out of several others as being exactly what the company desired. The premises of the company in Newington, built on the site of the old Clarendon Hotel, proved to be both elegant architecturally and adequate.

The offices in Newington continued to be the headquarters of the Company until 1870, when the site was acquired by the Cheshire Lines Committee for building the Central Station. The new offices in Duke Street (provided by the Railway Company in lieu of the Newington ones) were opened in July, 1872, and with extensions have provided the necessary accommodation ever since.

The Liverpool New Gas Company.—One would have thought that the disadvantages of having two competing companies would have been obvious at that time to anyone, judging from the previous experience of the two rival companies, but this does not appear to have been so; for in 1854 the formation of yet another company was announced, called the Liverpool New Gas Company, with offices at 14, Basnett Street. The ostensible object of the projected company (which did not intend to seek statutory powers, but relied on obtaining sanction from the corporation for laying down the pipes) was to break down the monopoly that had been established and reduce the price of gas. As in the case of the Guardian Company the project ended in failure.

There were some interesting statements concerning this project in an article in *The Liverpool Chronicle* of July 22nd, 1854, and they are worth reproduction. "Everyone feels," says the writer of the article, "that it will be quite a relief to break down the odious and grinding monopoly which has so long existed in this town with respect to an article which has now become a necessity of life. Seven or eight years have elapsed since the old competing companies were amalgamated. Nothing can be urged in favour of the present company but the poor plea that their monopoly does not necessitate the breaking up of the streets so frequently. Even

* Horace: *De Arte Poetica*, 143.

in this respect modern engineering science will be able to suggest and carry out a great practical improvement; one which will obviate the necessity of opening the middle of the streets. The new piping can be introduced in a way that will not interfere with street traffic to any extent, and which will, therefore, obviate the only objection that can be urged against the scheme."

To prevent inconvenience to the public, they proposed to lay the new mains under the footways during the night. The projected company announced that the price would be 3s. 6d. per 1,000 cubic feet, with a promise that the price would be reduced to 3s. per 1,000 cubic feet as soon as they were able to do so. The leading spirit in this further unsuccessful attempt to launch a company was one Mr. George Flintoff.

The Rose Hill Premises.—After the amalgamation in 1848 the Rose Hill premises were sold to the Corporation, who converted them to use as a police station. Until three years ago the public-house, 51, Richmond Row, which once adjoined the former works, bore the title "Oil Gas Tavern," a relic of a gas-making process in use and discarded a century ago.

It is rather a curious coincidence that the Dale Street premises at the corner of Hatton Garden were also sold to the Corporation, likewise for police purposes, the present police offices being subsequently erected on the site, as previously mentioned. The sale of the latter freehold property took place in 1853, the amount paid being £20,000.

Disputes with the Corporation.—In 1855 the Corporation appointed a committee to inquire into the state of the gas supply of the borough. Whether this action was justified or not, it certainly caused a great deal of ill-feeling. In December, 1857, an altercation arose at a meeting of the Town Council concerning the proceedings of the Gas Committee of the Council. The Gas Company were accused of making excessive charges for lamps, and sending out meters which had not been tested or stamped. It was urged on behalf of the Gas Company that no explanation of the alleged excessive charges had been asked for, and that the reason why unstamped meters had been sent out was that the Corporation Inspectors could not deal with the testing fast enough.

This episode is typical of the rather unfriendly relationship that existed between the Corporation and the Gas Company for many years. In 1874 Dr. Cross, a member of the Town Council, made a bitter attack on the Gas Company with regard to the price and quality of the gas, and carried on a hostile campaign for two or three years. The question of consumers' deposits was the cause of much criticism of the Gas Company. The unfriendly attitude of the Corporation culminated in a long-drawn-out dispute during the years 1894 to 1896 with regard to the price of gas for street lighting, the method of testing and the standard of illuminating power. It is pleasing to record to-day that during the last 20 years or more there has been a better spirit manifested on both sides. Long may it continue.

Landing Stage Fire and Sequel.—In 1874 the Gas Company was involved in a serious misfortune—the burning of the landing stage.

Under an Act of Parliament the landing stage had just been reconstructed and awaited ceremonial opening by the Duke of Edinburgh when, on July 28th, 1874, it was accidentally set on fire. The fire was attributed to the operations of a gasfitter in the employment of the Liverpool United Gas Light Company. In consequence of the woodwork in the lower part of the fabric being coated with creosote the flames spread with great rapidity, and the fire brigade were quite unable to deal effectively with the situation. As the result of legal proceedings, the Gas Company were compelled to pay a large amount by way of compensation. The hearing of the case lasted five days. The Judge's summing up took three hours, and the jury, retiring at 6-20 p.m., could not at first agree, but after prolonged consideration gave their verdict at 10 p.m.

As a result of this misfortune the company decided that they would no longer undertake the business of gasfitting, and a separate company was formed called the Liverpool Gas Fitting Company Limited, which carried on that work for 37 years. It was found, however, eventually, that the Gas Company's business was being adversely affected, and, in 1911, the Gas Fittings Company Limited was absorbed by the larger company; a decision that has, since it was made, been of great advantage in extending the sale of gas.

Fazakerley.—Following upon the inclusion of Fazakerley in the Liverpool municipal area, the Corporation decided to erect gasworks and supply that area themselves. They engaged Mr. Isaac Carr (the Widnes Gas Engineer) to design the works, and the opening ceremony took place in October, 1909. On that occasion the opinion was expressed that the erection of the works would be the beginning of great things, and would enable the Corporation to demonstrate that gas could be manufactured and sold at a low price—presumably lower than that in the city. Their hopes, however, were not realized, and there were many complaints of the high charges and poor quality. Eventually, negotiations took place between the Corporation and the Gas Company which resulted in the purchase of the Fazakerley Gas Undertaking by the Liverpool Gas Company. On the day of the transfer, in 1915, the Fazakerley Works were closed down, and the district has since been supplied from the Linacre Works of the company. Since that time the consumption of gas in that area has grown enormously and is nearly four times the consumption of 1915.

(To be continued.)

A Memorial to Michael Faraday

To commemorate the work of Michael Faraday, on whose discoveries the whole basis of present electrical engineering rests, the Southwark Borough Council propose to form a special collection of standard and current literature on electrical and allied sciences in the Central Reference Library of the borough. This library is situated close to the spot where the old forge of Faraday's father, a blacksmith, used to stand. It is proposed to create a Faraday Memorial Fund Library Fund, to be expended on the purchase of the best books year by year, so as to keep the library abreast of developments. The library is not limited to local residents, but is widely used—there was an issue of 100,000 books last year. We feel sure it will be agreed that this is an excellent method of commemorating Faraday's epoch-making work, which deserves every support. The project has already received the interest and support of numerous scientific bodies and firms in the electrical industry. Contributions should be sent to the Mayor, Southwark Town Hall, Walworth Road, London, S.E.17.

International Illumination Commission

SESSION AT BELLAGIO (ITALY), AUGUST 31ST TO SEPTEMBER 3RD.

Readers will recall the annual report of the National Illumination Committee, recently presented in this journal. It is now announced that the Executive Committee of the International Illumination Commission will this year be holding a short session at Bellagio (Italy), when various problems, such as factory and school lighting, automobile headlights, heterochromatic photometry, definitions and nomenclature and colorimetry (which are now being studied by the various sub-committees) will be discussed. Arrangements for the meeting are being carried out by the Italian National Committee on Illumination.

Illuminating Engineering Society (U.S.A.)

We learn that the twenty-first annual convention of the Illuminating Engineering Society (U.S.A.) is to be held in Chicago from October 11th to 14th inclusive, with headquarters at the Edgewater Beach Hotel, directly overlooking Lake Michigan. A comprehensive series of papers is being prepared.

CHANCE BROTHERS AND CO., LIMITED.

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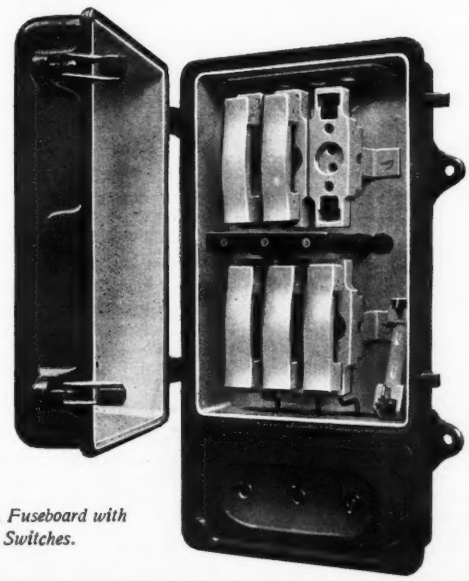

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SWITCHES IN SEPARATE COMPARTMENT

TRADE NOTES & ANNOUNCEMENTS

LIGHTING INDIA'S HOUSE OF PARLIAMENT.

The opening of the Council House, Delhi—India's new House of Parliament—recently by Their Excellencies Lord and Lady Irwin, was a splendid spectacle.

In this magnificent building, with its wonderful circular colonnades, the Chamber of Princes, the Council of State, and the Legislative Assembly of India will meet amidst the most gorgeous surroundings.

It was necessary that the electric lighting scheme should be in harmony and of appropriate grandeur, and also be in keeping with the imposing ancient palaces and monuments in the vicinity of, and associated with, this new building. In this connection, therefore, the General Electric Co. Ltd., Magnet House, London, W.C.2, despatched a special representative to Delhi in order to arrange for the design and supply of a large number of appropriate fittings which have now been installed and equipped with Osram gasfilled lamps. The value of the fittings already supplied, and those which are to follow, runs into many thousands of pounds.

The magnificence of this installation is bound to reflect itself in other Indian cities in awakening and stimulating a keener interest in, and appreciation of, the advantages of good lighting, particularly in the many stately buildings and palaces for which India is famous.

NEWBRIDGE TIME SWITCHES.

We are informed that the Horstmann Gear Company Ltd., Newbridge Works, Bath, have been successful in securing an order from the Engineering Department of the General Post Office for 750 service boxes with time switches and 250 service boxes without time switches, all for use in telephone kiosks. This is an interesting illustration of the growing adoption of automatic clock control for all types of public lighting.

THE BOYCE MOTO-METER VINDICATED

Under this heading a leaflet issued by the Benjamin Electric Ltd. refers to the judgment given in favour of the company on March 3rd in the Supreme Court of Judicature (Court of Appeal). On this occasion the appeal by the defendants (Morris Motors Ltd.) from the decision in the Chancery Court that the use by the defendants of the engine temperature-recording device (the " Calormeter ") was an infringement of the Boyce Moto-Meter patent was dismissed. The case has attracted a considerable amount of interest, and we congratulate the Benjamin Electric Ltd. on its issue. The remarks of Lord Justice Sargent, the Master of the Rolls, and Lord Justice Lawrence are quoted to show the utility of this device, which acts as a warning of coming engine trouble and is based on the sound principle that the temperature-recording element operates in air and not in water. It is stated that as many as 10,000,000 Boyce Moto-Meters are now in use.

VENNER TIME SWITCHES.

We have to record the receipt from Messrs. Venners Time Switches Ltd. of an ingenious little device—a blotting pad for office use with knob and backing of embossed metal. Besides the name of the firm, the metal bears the dates 1906-1927 and an allegorical device with the motto " Tempore Parendum." This little device has been issued to mark the celebration of the twenty-first anniversary of Venner Time Switches, who, during this period, have attained a high reputation for the consistent quality of their products, many of which are designed to solve special problems and meet exceptional demands.

THE STORY OF THE MAZDA LAMP.

In a little leaflet distributed at the Ideal Home Exhibition the story of the Mazda lamp is told. The booklet is attractively printed and illustrated many types of lamps—Pearl Mazda, Daylight, Colour-Sprayed, etc., and the variety of fittings now available for home use is also shown. Finally it is emphasized that all Mazda lamps are British made, being produced at the Rugby factories of the British Thomson Houston Co. Ltd. (who have, in all, seven factories employing nearly 12,000 people).

A TRIBUTE TO PHILIPS AUTOMOBILE LAMPS.

We have received an interesting photograph showing the results of a motor accident caused by a motor-cycle combination colliding " head on " with a car. Although the headlamps of the car were completely smashed it was found, upon test, that the two lamps were still quite serviceable. This is regarded as a striking illustration of the robust nature of the Philips automobile lamp.

CONTRACTS CLOSED.

The following contracts are closed :—

MESSRS. SIEMENS AND ENGLISH ELECTRIC LAMP CO. LTD. :

London, Midland and Scottish Railway; for the supply of Siemens vacuum and gasfilled lamps, and also carbon filament and train lighting lamps, for the period ending December 31st, 1927.

London and North Eastern Railway; for the supply of Siemens gasfilled, vacuum and carbon filament lamps for 12 months ended March 31st, 1928.

Corporation of Kingston-upon-Hull, Tramways Department; for the supply of Siemens carbon filament lamps (ruby), and also Siemens metal filament lamps, for the period ending March 31st, 1928.

MESSRS. METRO-VICK SUPPLIES LTD. :

London, Midland and Scottish Railway; part contract for 12 months' supply, from January 1st, 1927, for " Cosmos " gasfilled train, gasfilled ordinary, vacuum train, vacuum ordinary, vacuum traction, vacuum ship type, vacuum carbon and radiator lamps.

London and North Eastern Railway; for " Cosmos " vacuum metal filament, carbon filament, gasfilled and automobile type lamps; also part contract for reflectors, shades, etc., for 12 months ending March 31st, 1928.

In addition, contracts for electrical accessories have been placed for six months by the *Parish of St. Mary Islington Guardians*, the *Paddington Board of Guardians*, and the *Stepney Union Guardians*.

THE GENERAL ELECTRIC CO. LTD. :

London, Midland and Scottish Railway; for all their requirements in Ireland in train lighting lamps, comprising vacuum, gasfilled and standard gasfilled lamps from 60 to 1,000 watts.

Brentford Union; twelve months' supply of Osram metal filament, vacuum and gasfilled lamps.

Borough of Holborn; twelve months' supply of Osram metal filament, vacuum and gasfilled lamps.

Belfast Union; twelve months' supply of Osram metal filament, vacuum and gasfilled and Robertson carbon filament lamps.

London, Midland and Scottish Railway; twelve months' supply of part of their annual requirements for vacuum, gasfilled and metal filament and carbon filament lamps.

Beautiful Lighting

"CARRARA"

DUST-PROOF UNITS

The gracious design of the "Carrara" lighting unit, with its antique brass ornamental work and beautifully modelled white glass, is the crowning touch to the architect's skill.

"Carrara" yields the utmost illumination because its glassware conforms in texture and design to the best results obtained from extensive research and experimental work. There is the maximum diffusion with the minimum absorption of light. No dust can penetrate "Carrara" fittings.

In banks, insurance offices and shop interiors, "Carrara" units are seen at their best. They are made in a variety of beautiful designs.

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To take maximum size lamp 200w. G.F. antique brass ornamental metalwork, glass 12 in. dia. × 5 in. lip, 45/-. Complete with 2 ft. of patent chain and lampholder. Lamps, wire and wiring extra. State wattage of lamp when ordering. Oxidized copper 5% extra, oxidized silver 12½% extra.

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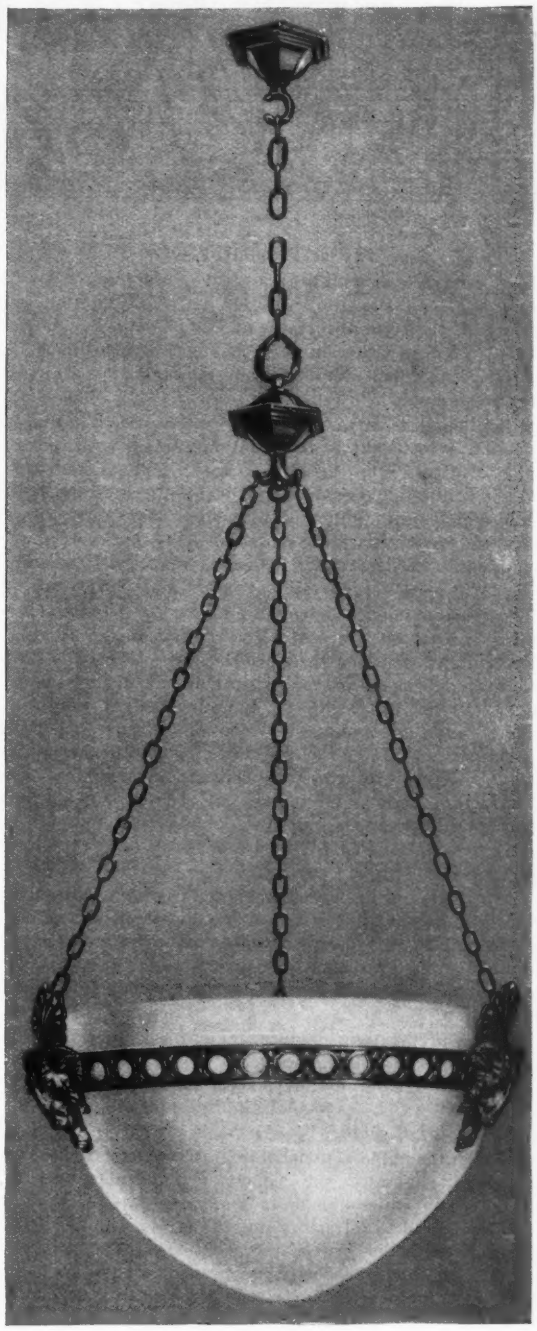

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STREET LIGHTING.

Sir,—I have read with a great deal of interest the excellent article by Messrs. L. B. W. Jolley and C. A. Morton, which appeared in the June, 1925, issue of *The Illuminating Engineer*, entitled "A New Criterion of Street Lighting Excellence," and desire to compliment the authors on the manner in which their ideas are presented.

It would appear, however, that the authors deem it impossible to obtain street-lighting installations which will meet the "physiological" and "psychological" requirements and will also obtain the "approval of the local authorities and police." While admitting the difficulties experienced in reconciling the various factors enumerated, I do not believe that it is impossible to promote street-lighting installations which will meet all the requirements of an adequate system and approach the ideal.

The method suggested by the authors for specifying street-lighting excellence is a useful contribution to the art, but the deductions are to some extent fallacious. The curves which have been developed are limited in their use in that they show only the ratio of spacing to mounting height producing a definite value of minimum illumination occurring midway between the units. The desirability of adopting the minimum value of illumination is questionable, and its combination with other factors, such as the maximum, average, and uniformity factor would appear more desirable, and would approach more closely to what might be termed a criterion of street illumination.

The calculation or measurement of horizontal illumination values at a height of 39 inches above the street surface is open to question. This height would be correct for vertical illumination, but a distance of one foot, or even less, above the street surface would appear more reasonable for horizontal illumination.

The use of the term "glare angle" is rather misleading, and, as a matter of fact, the word "glare" itself should not be used to designate anything except the objectionable feature of light for which it was originally intended, namely, the blinding effect of glare.

Although the authors do not state it, the practical value which the method suggested may possess is applicable only to an installation in which the units are mounted over the centre of the street and to refractors suitable for such units. Despite this limitation, the article refers in several places to the "posts" on which the units are mounted. If the authors also intended the method for use in connection with installations of ornamental units at the curb line, as is common practice in America, another serious fallacy is introduced in the assumption of minimum foot-candles midway between standards as a criterion of illumination on the street, which, in this case, would be on the curb line. Furthermore, only two units are considered in the calculations.

A great deal of interest is manifest in the United States at this time in connection with street-lighting specifications and the adoption of a criterion of street-lighting excellence. The discussions on this subject, however, disclose wide differences in opinion among authorities on illumination. Many of the suggestions have only served to complicate the problem.

Modern traffic conditions require higher intensities of illumination than were customary in the days of the horse-drawn vehicle, and on well-lighted streets we see primarily by direct illumination, and not by silhouette. Under these conditions the vertical illumination is of paramount importance, but since a high vertical component is present with good horizontal illumination, it is not necessary to take this into consideration. A criterion based on average horizontal illumination, coupled with a uniformity factor representing the ratio of minimum to maximum may be established, and a specification based on these criteria will insure a municipality obtaining definite values of street illumination.

TABLE OF MODERN STREET-LIGHTING PRACTICE.

Class of Street.	Average horizontal illumination (ft.-candles).	Uniformity factor. Min. f.c. / Max. f.c. = % Uniformity
1. Main Business Streets ...	.80—2.50	... .75
2. Secondary Business Streets	.60—2.00	... .75
3. Main Traffic Arteries ...	.30—1.00	.. .70
4. Secondary Traffic Arteries	.25— .70	... .60
5. Residence Streets	.20— .50	... .40
6. Park Drives	.10— .40	... .35
7. Warehouse Districts ...	.10— .40	... .25
8. Minor Residence Streets ...	.10— .25	... .25
9. Alleys	.10— .25	... .25
10. Highways	.05— .10	... .15

The attached table of modern street-lighting practice has been recently suggested by the illuminating engineers of one of the large American manufacturers of street-lighting equipment, and it would seem that this presents a simpler method of evaluating street-lighting excellence than that suggested by the authors of the article entitled "A New Criterion of Street-Lighting Excellence."

Yours very truly,

L. A. S. WOOD,

Manager, Street-Lighting Section

(Westinghouse Electric and Manufacturing Co.).

SIR,—With reference to Mr. L. A. S. Wood's reply to our article in the June, 1925, issue of *The Illuminating Engineer*, without necessarily prolonging a discussion which must of necessity be amended in the light of recent developments in street lighting consequent on the issue of a draft specification, we would wish to draw attention to the following points:—

In paragraph 2 Mr. Wood suggests that it is possible to meet all requirements of an adequate system and approach the ideal. He does not, however, give his requirements for ideal conditions. It is generally admitted that the nearest approach to ideal street-lighting conditions is obtained in clear daylight. The value of the uniform illumination produced, however, is high, and to repeat such conditions by artificial means is not sound economically. Further, an installation fairly uniform in character and low in intensity tends to produce, psychologically, a sense of depression and a general impression of flatness over the whole of the area so illuminated.

In paragraph 3 Mr. Wood regards the deductions as "being to some extent fallacious" in that they are based on the adoption of a minimum horizontal illumination. He is, however, indefinite as to an alternative. It is equally essential to a motorist, for example, that he can see the character of the road by the horizontal illumination upon it as to see objects upon the road vertically illuminated. There is usually little trouble in providing sufficient vertical illumination at a reasonable distance from the source. The horizontal illumination, however, usually has to be provided by specially designed dioptric systems. As both are essential to visibility and related by the geometry of the installation, it is preferable to adopt the lower of these two quantities.

With regard to paragraph 4 of his letter, we are inclined to agree that the horizontal illumination should be measured as near as possible to the street surface. The datum level of 3ft. 3in. was maintained in this article as it represented the practice in this country. We certainly agree with Mr. Wood that a ground level illumination is actually what is required, and in future this will no doubt be altered.

With regard to paragraph 5, the article does not make use of the term "glare angle" but merely quotes it as having been sometimes used. We certainly agree that even the word "glare" itself is misleading and should prefer some expression representing the effect of ocular insensitivity.

With regard to paragraph 6, there is no reason why Mr. Wood should imagine that the method only applies to a central suspended system. In most of the more important lighting systems in this country the location of fittings is either above the centre of the roadway or on posts at staggered spacing. There is nothing in the article to suggest that it is not equally applicable to a staggered installation, where a lower minimum illumination would still be at the mid-point, which would still be at the centre of roadway. Two units have only been considered in the calculations, as the increase of illumination due to one more remote would be negligible, owing to the greater angle subtended by this more remote post and the consequent marked reduction in the value of $\cos^3\theta$.

Finally, in the last paragraph, Mr. Wood suggests that his tabulations present a simpler method of evaluating street lighting excellence than the article. The article did not attempt to evaluate street lighting excellence in any way. It simply dealt with the fact that with various fittings it was possible to have a fair tolerance in spacing height ratio for a negligible difference in minimum horizontal illumination.

This whole question of the evaluation of street lighting excellence has been dealt more recently with in the new B.E.S.A. Street Lighting Specification to which reference has already been made. Classification has been made into seven classes.

Yours truly,

L. B. W. JOLLEY.
C. A. MORTON.

LIGHTING OF HOUSE NUMBERS.

SIR,—I was interested in the notes that have recently appeared in *The Illuminating Engineer* about the regulations being introduced in cities abroad for the illumination of house-numbers. This is a crying need. As the lighting up of names or numbers of houses is a simple matter local authorities should have no hesitation in taking the necessary steps. Evidently, authorities in foreign cities have power to enforce such lighting, and one would think that their powers in this country should also be sufficient, seeing that in some districts houses have been already allotted numbers and it is obligatory for these numbers to be clearly marked outside the house.

Yours truly,

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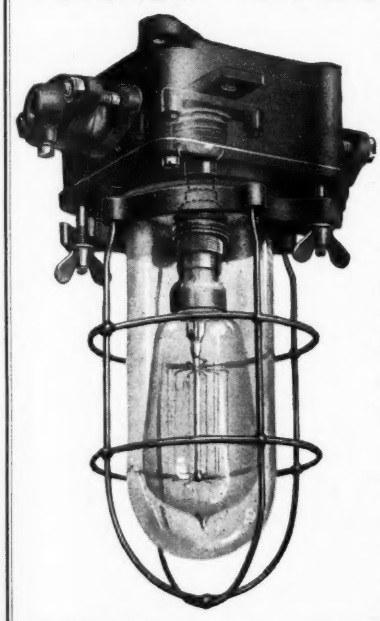

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REVIEWS OF BOOKS AND PUBLICATIONS RECEIVED

A SHORT HISTORY OF PHYSICS; *by H. Buckley. (Methuen & Co. Ltd., London, 1927; pp. 263.)*

In the introduction to his book Mr. Buckley (who is at present associated with the Photometric Section of the National Physical Laboratory) remarks that the number of works dealing historically with the development of physics is small. One explanation is doubtless to be found in the magnitude of the task. One cannot survey the whole field of physics. The greater part of Mr. Buckley's book deals with the atomic theory and the structure of the atom in various aspects, and much of the other matter, such as the discussion of planetary motion, the quantum theory and relativity, may be said to have a direct bearing on this field of knowledge. The survey of recent physical theories in the final chapters will probably prove useful to many readers. The author has dealt lucidly with this complex subject. One may, perhaps, single out his review of the successive steps on which the theory of relativity has been built up as one of the most striking sections of the book. The author has also been successful in showing clearly how epoch-making theories and discoveries rarely come to light suddenly in their final form, but, on the contrary, are built up gradually from the contributions of many workers. Of most direct interest to our readers is probably the chapter on radiation, with its account of the work of Lummer and Pringsheim, Kirchoff, and others, and its indication of the relation between the electron theory and various luminous effects; this has an obvious bearing on future possibilities in the direction of more efficient sources of light. The introductory chapter and the section on planetary theory both serve to show the really remarkable achievements of the ancients, especially in the field of astronomy. The Babylonian astronomers could apparently predict lunar and solar eclipses with considerable accuracy, and Hipparchus at Alexandria (150 B.C.) determined the chief astronomical data, such as the length of the sidereal year, the obliquity of the ecliptic and the eccentricity of the sun's orbit.

The Cambridge Bulletin for March, issued by the Cambridge University Press, records a remarkably varied series of educational and scientific works. Chief amongst these we note Prof. Eddington's great work on "The Internal Constitution of the Stars" and "Science and the Modern World," by A. N. Whitehead. Other recent books of interest include "A Year amongst the Persians" (Edward Granville Brown); "An Economic History of Modern Britain" (J. H. Clapham); and "A History of Late Eighteenth-Century Drama (Prof. Allardyce Nicoll).

PHOTOMETRY

BY

JOHN W. T. WALSH

M.A. (Oxon.), M.Sc. (Lond.), A.M.I.E.E., F.Inst.P.

Member of the National Illumination Committee of Great Britain; General Secretary of the International Commission on Illumination.

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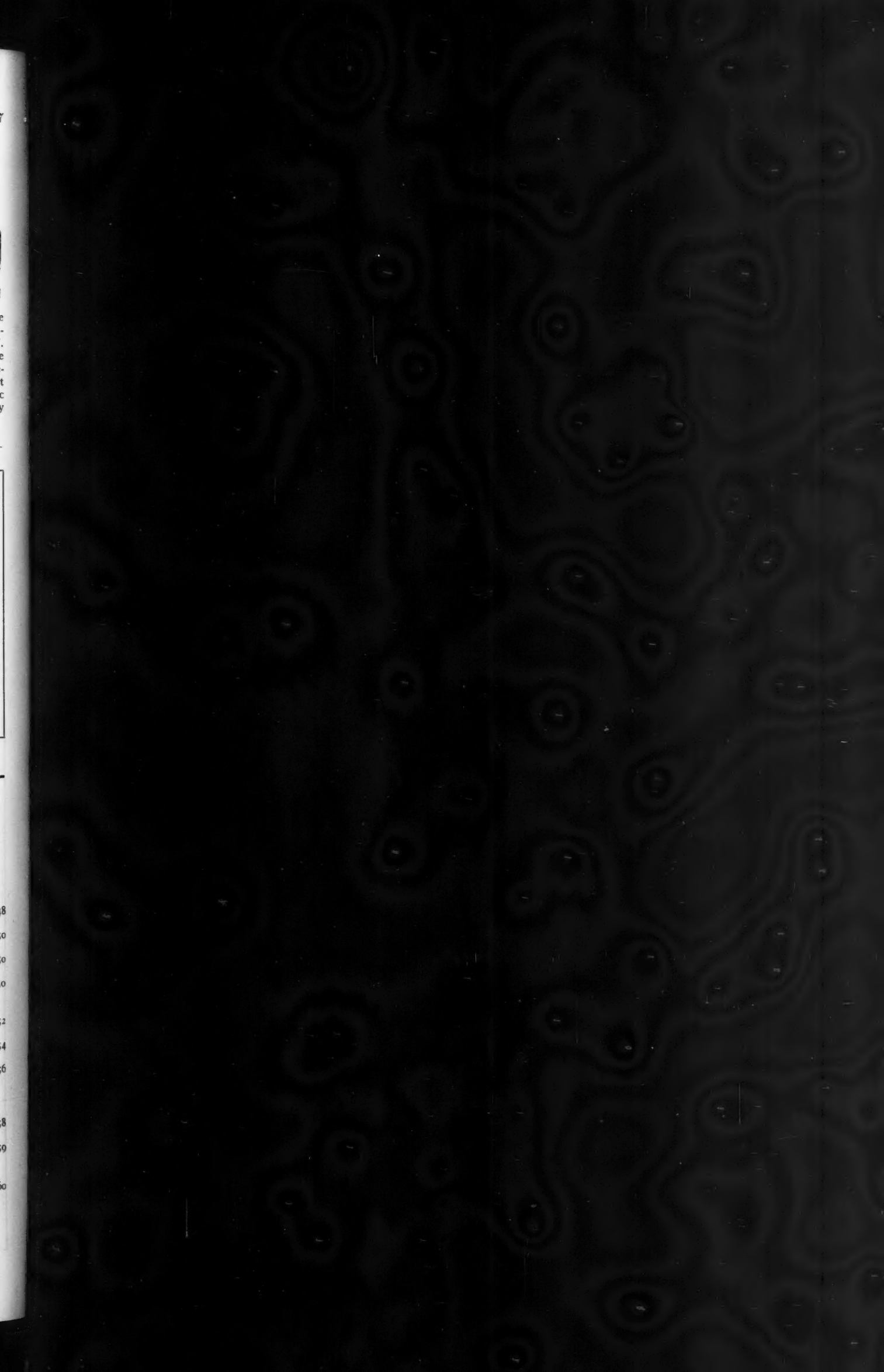
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